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SPORTS

AND

AMUSEMENTS

FOR THE

JUVENILE PHILOSOPHER.

A PRESENT FOR THE YOUNG.

PART FIRST.—SECOND EDITION.

MIDDLETOWN:

PUBLISHED BY E. HUNT AND CO.

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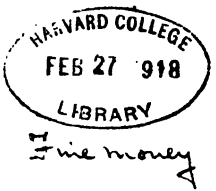


Fine money

Entered according to the Act of Congress, in the year 1835,
By Edwin Hunt,
in the Clerk's Office of the District Court of Connecticut.

G. F. Olmsted, Printer.

PREFACE.

Most of the following compilation is abridged from the pages of the elegant author of "Philosophy in Sport." The Editor has occasionally borrowed, however, from Miss Edgworth, Hutton's Recreations, Dr. Brewster's Letters on Natural Magic, and others. Instead of translating the ideas of these writers into a different phraseology, he has used the identical expressions of the original authors, so far as was consistent with simplicity and brevity. He has, also, freely used the privilege of condensing and simplifying the original matter, and of interspersing such remarks and illustrations of his own as the subject seemed to require. In the use of scientific terms, he has labored to be as correct and precise as if he had been professedly writing a treatise on Natural Philosophy.

The object of this little work, is to awaken in the minds of the young an early love of science, by blending amusement with instruction, and if possible, to redeem some small portion of that large amount of time and intellect, (for where do the young exhibit more intellect than in their sports,) which are devoted to recreation. It is hoped that it will also be found useful in promoting the habit of applying the principles of science to the ordinary affairs of life—a habit indispensably necessary, if the possessor would derive any important advantage from his knowledge; but still a habit which the abstract nature of sterner productions is often far from favoring.

How far the following selections have been made with judgment, and presented in an amusing and instructive form, is left with an indulgent public to determine.

SPORTS AND AMUSEMENTS.

On a beautiful afternoon in May, George Somers, a bright-eyed, rose-lipped boy, returned home from the last day of his examination.

He had always been a diligent pupil, and from his efforts to do well on this occasion, was a little fatigued. Still he was in fine spirits, and his cheek glowed with the feeling of conscious merit; for he knew that the testimony of his industry and good conduct which he had received from his instructor, would delight the hearts of those whom he dearly loved. As he bounded lightly into the parlour, he was welcomed by his mother and

sister with a smile of approbation. Then he thought he would not have exchanged his feelings for all the world, and he determined that he would never deviate from a course that was productive of so much happiness. Can there be an incentive to virtue so powerful as the exhilarating smiles which the schoolboy receives from an affectionate parent?

On this occasion George did not forget to lay up his philosophy on the shelf, but he accompanied the act with a secret resolve to have nothing more to do with books, until the school-bell should summon him away from his sports and amusements.

The vacation before him was a long one to be sure, but he had no fears that time would hang heavily on his hands; and at first it did not. For many days he did nothing but play at balls, marbles, and other games: But at last he grew weary of all his sports: His ball was lost, and he forgot to procure

another; he laid up his marbles, and for a reason unknown to himself, he lost his interest in his other amusements. In fact, he wished himself again engaged at school with his books. When the family were one evening assembled together, "I wish," said George, "I was busy at school again."

"Are you so soon weary of the society of your friends?" said Mrs. Somers.

"Surely, dear mother," said George, blushing, "I am not weary of your society, but it seems to me I was happier even with you, when I had employment.

Mr. Somers, who was always attentive to the remarks of his children, reminded George that he could occupy himself with his studies, even in vacation, if he chose to do so.

"But then I feel very little interest in my studies, papa, unless I am to recite what I learn, and have it explained; and I think," continued he, "I already understand the prin-

ciples of my philosophy as well as I can do without farther explanations and experiments."

"Perhaps," said Mr. Somers, "you are not aware that your games and sports illustrate nearly all the great truths of Natural Philosophy.

"Indeed, father," said George, "it never occurred to me that they do."

"Yet such is the fact," continued Mr. Somers, "and now, my boy, I have an offer to make to you, which is this: I will successively supply you with some new amusement, whenever you can satisfactorily explain those you already possess, and since you understand the principles of Natural Philosophy, you will have little difficulty in understanding the manner in which each produces its amusing effects."

"I am sure," exclaimed the delighted George, "I shall obtain the prize, whenever I

put my skill to the trial, at which I hope mama and Louisa will be present."

"Certainly," replied Mr. Somers, "and I trust that your sister, who is of an age to understand the explanations, will not prove an uninterested spectator."

"To-morrow, then, if you please, papa," said George, "we will commence."

"To-morrow," echoed Louisa.

"Be it so," replies her father, "and that George may have an opportunity to refresh his memory on the subject before hand, we will first consider the action of those toys, which are indebted for their operation to the force of the atmosphere.

"Thank you! thank you, dear papa," was simultaneously shouted by George and Louisa; and the happy children looked forward to the morrow with that mixed sensation of impatience and delight which always attends juvenile anticipations.

After retiring to rest, the mind of our little philosopher was so much excited, that for a long time he could not sleep. He wondered which of his toys depended for its operation upon the force of the air. Then he called to mind what he had learned respecting the air. He remembered that air was a substance or matter, as really as wood or stone; that it was a fluid substance, that is, that its parts moved easily among themselves like those of water—and further, that it was said to be an *elastic* fluid.

CHAPTER II.

The house of Mr. Somers was situated on the declivity of a hill, so that a verdant lawn, which was spread before its southern front, after retaining its level for a short distance, gently sloped to the vale beneath, and was terminated by a luxuriant shrubbery. Mr. Somers' library window was at the eastern side of the house, and commanded a most extensive prospect. On the turf before the window, while his mother was occupied with her morning avocations, George, with his little play-fellow, Louisa, were running races and playing, but every now and then George could not help thinking of papa and his promise, and he would lead Louisa to the other side of the lawn to steal a peep into the library, in the hope of finding that his papa was prepared to quit it. After many an anxious peep,

he at length had the satisfaction of seeing him throw aside his papers, and take up his hat. At this signal they both exclaimed, "Papa is coming! Papa is coming."

"George," said Mr. Somers, as he advanced towards his children, "I have not forgotten my engagement, and am now prepared to devote the rest of the morning to its fulfilment.

"We are to consider, you know, the action of those toys which are indebted for their operation to the properties of the atmosphere. George, fetch me your leather sucker".

"I exchanged it the last rainy day, papa, with Henry Elton, for a set of marbles," replied George.

"Then you shall make another for yourself."

George immediately went for the leather and string. Louisa, who was thinking of the expression "properties of the atmosphere"—"properties, papa," said she, "that is a word

of which you once taught me the meaning—properties are what belong to things."

"One of the properties of air," said her father, "is fluidity. This property also belongs to water. Sand, on the contrary, is not a fluid. Sand may be poured out like water, but the grains of which it is composed are separated, and have no visible attraction for each other. The parts of water stick together, though but slightly—a small force divides them, but still they obviously are inclined to hold together."

By this time George had returned. "The leather is so stiff," said he, "but I may perhaps make it answer the purpose by first soaking it." Having allowed it to remain in water for a short time, the leather became sufficiently pliable for his purpose; he then cut it into a circular shape, and fixed a string through its centre. The party now proceeded to the lawn, and having once again dipped

his newly constructed sucker into the water, the ingenious boy placing it upon a stone, pressed down the leather with his foot, and succeeded in making it raise the weight. "Well done, my boy. Now, then, explain the reason why the leather sticks to the surface, and of its being thus capable of retaining its hold, notwithstanding the weight of the stone."

"In the first place," answered George, "the edges of the leather, from being closely pressed, stuck with sufficient firmness to the smooth surface of the stone to resist the force of the string as I pulled it upwards. The consequence was, that a hollow was formed in the middle part of the leather, and as that hollow place cannot contain any air, it is called a *vacuum*."

"Very well," replied his father; "so far you are right, but you have not informed me in what manner a vacuum acts in preventing the stone from quitting the leather."

"It makes it adhere to it by some kind of suction, but I confess that I do not exactly understand the subject."

"Then let us proceed cautiously and deliberately in the explanation. In the first place, you have said, and said correctly, that the edges of the leather adhere to the stone—but what is the nature of the power to which this adhesion is to be referred? I perceive you are puzzled by the question; attend, then, to my explanation: you must know that there exists in all bodies a tendency to adhere or stick together, provided the contact of their surfaces be sufficiently perfect; this property is termed cohesion, or cohesive attraction, from the Latin word *cohæro*, which signifies to stick together. The dry leather will not adhere to a smooth surface, because in that case the contact cannot be made sufficiently perfect; but when soaked in water, the little cavities of the leather are filled with that fluid,

and the inequalities which must always prevent close contact are removed. If two bodies, when placed together, be not sufficiently smooth, it will be vain to make any attempt to produce their cohesion, since the particles will in such a state touch each other in a few points only; it is for this reason that carpenters, when they intend to glue pieces of wood together, plane the surfaces perfectly smooth before they apply the glue." George here acknowledged that he did not before understand the reason of the leather's adhesion to the stone. "Having, then, settled this point to your satisfaction," continued Mr. Somers, "let us proceed."

"Your idea of a vacuum being formed in the hollow between the leather and the stone, is perfectly correct, for as you draw up the central part by the string, the hollow thus produced must necessarily be a vacuum, since the air cannot pass through the leather to

supply it in this state; therefore the atmosphere presses upon the exterior of the leather, and like any other substance prevents it from rising from the stone." Louisa here expressed some surprise on hearing of the weight of the atmosphere, and observed that "she did not feel any pressure from it."

Her father explained the reason of their not being conscious of the weight, by informing her that our bodies contain air, which by its elasticity, or springiness, counteracts the pressure from without, just as a bladder that is blown up, that is, filled with air, cannot be pressed together, but that if it were possible to remove all the air which the body contains, the pressure of the atmosphere would not be counteracted, and the consequence would be, that we should be crushed to atoms by its weight, which had been ascertained to be equal to fifteen pounds upon every square inch of surface, or as much as forty thousand

pounds upon the body of a man of ordinary size.

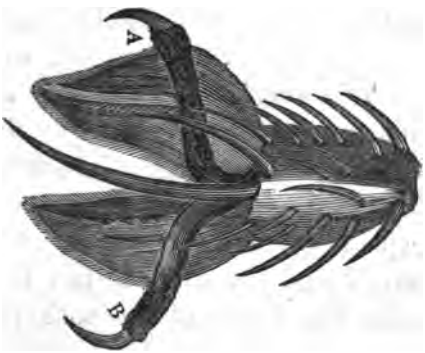
"Until your explanation," said George, "I really believed that the leather adhered to the stone by some kind of suction, just as the back of my hand adheres to my lips whenever I place it to my mouth, and draw in my breath."

Mr. Somers here expressed a doubt whether his son was even yet a perfect master of his subject: he told him that there was no such operation in nature as suction: that it was merely a common term to denote the action of the air upon a vacuum. "Your hand," said he, "adheres to your mouth in consequence of your forcibly drawing in your breath, and the resistance which is opposed to its removal arises entirely from the pressure of the atmosphere upon it. Many are the effects which may be explained in a similar manner." Mr. Somers went on to inform them that many

sea-insects possessed the power of converting their whole bodies into suckers, and that many animals are endowed with a similar faculty. He instanced the claws of the polypus, which are furnished with many such suckers, by means of which the animal is enabled to hold to whatever it attaches itself with very considerable force."

At this moment George's stone fell from the sucker. Louisa inquired how it could have happened. "The circumstance is easy to be explained," said her father. "The atmosphere, by its pressure, at last forces its way under the edges of the sucker; its interior therefore becomes filled with air, and it consequently balances the external weight which had before confined it. Have you never observed," asked Mr. Somers, "the security and ease with which flies frequently walk upon the ceiling, or any smooth wall, or even a pane of glass, with their bodies downwards?"

"To be sure, replied George, but are not their legs provided with some sticky matter, which enables them to preserve themselves from falling?"

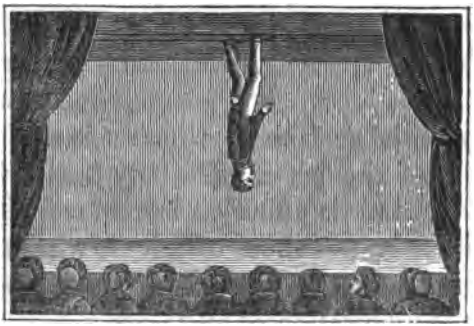


"That is an error my dear, the fact is their feet are provided with little cups or suckers, as represented by A. and B. above. These they alternately exhaust and fill with air, by which means they are enabled to walk in every position over the most slippery surfaces.

When the fly walks erect, however, these caps are turned up out of the way, and his motion is effected by fixing the claws, which you see represented in the figure, into the surface upon which he walks. In like manner, the walrus, or seal, is capable of climbing the masses of slippery ice with perfect security. By a similar process," continued Mr. S., "The sucking fish fixes itself on to the shark, or the bottoms of ships. This fish is of the shape of half an egg, and surrounded by a broad loose edge, which it has power to apply to the surface on which it is set. The middle of the fish is raised by the action of muscles, and its adhesion is effected. These beautiful contrivances of Divine wisdom, my children, ought to arrest the attention and excite the admiration of all."

"But, father," said George, "why might not men walk on the ceiling, by fastening on their feet large leathern suckers?"

"The experiment," said Mr. S., "has never been made, I believe, and if it were tried undoubtedly would not succeed, for the want of muscles by which to apply and exhaust the suckers. Still the lovers of the marvellous have succeeded in walking on the ceiling with the head downwards, in the following manner. Two openings were made in the



ceiling at the same distance as the footprints of a person walking on sand, as represented by the above figure. These openings were

narrower than a man's foot, so as to permit a rope, or strong chain, fastened to the feet of the performer, to pass through the ceiling unseen, where they were held by two or more persons above it. In this manner the inverted performer might be carried along by a side-long or shuffling motion, similar to that which is adopted in walking in the dark, and in which the feet are not lifted from the ground."

The party now returned home, but on their arrival they found it would be a whole hour before dinner. Mr. Somers proposed that the time should be passed in trying other amusing experiments to illustrate the properties of the air. To this proposition George and Louisa readily agreed.

Mr. Somers then sent for a tumbler, and a basin of water. After filling the tumbler with water,—"Now," said he, "if this tumbler, that is full of water, be emptied of the water, the

air that is in the room will enter into the tumbler, will it not?"

"But how can you be sure of that, papa?" said Louisa, "because, we cannot see the air."

"But you can feel it, if you wet your finger, and move it about quickly in the tumbler."

Louisa did so. "Now," said she, "I am satisfied."

"Observe," said her father, "what happens when I put this tumbler, with the mouth downwards, into the water in the basin. Does the water within side of the tumbler rise higher than the water on the outside of it, or not so high?"

"It does not rise quite so high," said Louisa.

"What do you think is in that space, which you see above the water, in the tumbler?"

Louisa hesitated. But George immediately answered, "that there was *air*."

"And now suppose that I could take away that air, which is in the glass, immediately over the water—what do you think would happen?"

George said, that "he thought that the water would rise in the glass, and fill the place which the air had filled."

"Oh! to be sure," said Louisa, "I know the water would rise in the glass."

"And do you know, Louisa, why it would rise in the glass, or what would make it rise?"

Louisa hesitated; but her brother said he believed that the air in the room, the air that was all over the water in this basin, in which the tumbler is turned down, would press upon that water, and by pressing it, would force it up into the glass, if there was no air or anything else in the glass to hinder the water from rising.

"Very well," said Mr. S. "I will now try an experiment that will show you how far the

water will rise, when some of the air is taken away."

"But I cannot imagine, papa," said Louisa, "how you will contrive to get all that air out of the glass."

"I cannot easily get all the air out of the glass. I cannot produce what is called a perfect vacuum, that is, a place where there is nothing—no air, or anything else—but I can easily take away some of the air."

Mr. Somers then went for a bent tube of glass—it was nearly in the shape of a capital U. He told George that tubes of this sort are called syphons. He put one leg of this tube under the bottom of the tumbler up through the water, into the place which appeared empty. He now bid George suck at the other end of the syphon. George did so; and as fast as he sucked, the water rose in the tumbler.

"Since George's explanation," said Louisa,

"I understand why it is that the water rises in the tumbler when the air is taken away, but I do not understand how sucking takes away the air."

"Then you will doubtless be surprised and delighted at the explanation of it. He first applies his mouth to the end of the syphon, and having drawn in his breath, the entrance to his mouth from the throat is stopped. Then he squeezes the syphon between his lips, to prevent the air from entering there, and a vacuum is made in his mouth, and the air in the top of the glass being pressed upon by the water, is forced into his mouth. By a similar manner of forming a vacuum in the mouth, young animals perform what is called suction. The vacuum being formed in the mouth, the pressure of the air upon the udder of the dam forces the milk into the vacuum."

But we have not got through with our experiment. George then repeated the process

of drawing the air from the top of the tumbler, but on taking his mouth away the water fell again.

"Why does this happen?"

"It happens, I believe, father, because when I left off sucking, and took my mouth away, the air went again through the syphon into the tumbler, above the water."

"Just so, George. Now the same thing would happen, if I could take away the air or lessen it by any means in the tumbler. If I could fill, or partly fill, the tumbler with any thing that could be taken away from beneath it while it stands in the water, then we should see the water rise in the tumbler in the same manner as if the air were sucked out of it."

"Here," said Louisa, "is a little spool, or roller, upon which silk is usually wound. Now I will put this little frame of tin, that will support it, under the glass tumbler above the water. Upon this, I have wound some very

broad tape, so as to fill up a large space in the tumbler; I pull one end of the tape under the bottom of the tumbler, through the water that is in the saucer, so that I can unwind the whole of the tape without disturbing the tumbler. You see that the water rises in the tumbler as I unwind and draw out the tape: and now that all is drawn out, the water has filled as much of the tumbler as had before been filled by the tape.

"This is very pretty," said George. "I understand it. When the tape was taken away, the room that it filled would have been supplied with air, if air could have got into the tumbler."

"Now I will show you, my dear children, another way of trying this experiment. I make a little stand of cents under the tumbler, upon which I can put a piece of paper, without its being wet by the water in the basin. I set fire to the paper, and while it is

flaming I put the tumbler quickly over the flame into the water—now you see the flame goes out, and the water rises."

"Yes, papa; I suppose the flame burns out some of the air."

"It does, George, consume a little of the air in the tumbler, but that is not the cause why so much water rises. You saw that the flame took up a considerable quantity of room in the tumbler, while it was burning; but the moment that the glass covered the flame it went out; and then the room that the flame took up was supplied by the water rising from the saucer. Now if instead of putting a piece of lighted paper upon the little stand of cents,

I put a piece of tow dipped in turpentine or spirits of wine, it will make a much larger flame; and when it is extinguished by putting the glass quickly over it, more water rises than in the former experiment."

George turned again to look at the tumbler, and repeated, "that it was really very pretty to see the water rise in the tumbler, pressed up by the air that was over the water in the basin." But he seemed a little doubtful whether Louisa understood it. "You see, Louisa, the air presses the water first, and that forces it up into the tumbler."

"Yes, I understand it perfectly," said Louisa.

"There is another very pleasing experiment which I will show you, to illustrate the pressure of the atmosphere." Mr. Somers then filled a wine-glass with water, and laid a piece of paper on the mouth of it. Putting the palm of his hand on the paper, he turned

the glass upside down on the paper which lay on his hand. Then removing his hand, "You see now," said he, "that though I have taken away my hand, the card sticks to the glass."

"But why does not the water fall out?" said George to Louisa.

"Because the paper keeps it in," said Louisa.

"Why does it keep it in?" said George.

"Because the paper stick to the glass."

George here said, "that it did not stick to the glass, but it is held close against the glass by the pressure of the air."

"That is quite right," said his father, "by the pressure of the atmosphere. I am glad, George, that you know that the air presses upwards as well as downwards, and sideways, and in all other directions."

Mr. Somers went on to explain to them farther how the water was kept in. The sides

of the inverted glass prevent the air from pressing on the upper part, but it has free access underneath, and the pressure is evident from the fact that the paper is hollow. The water rests on the paper, which keeps it smooth, and prevents one part of the column from becoming longer than another, and forming a passage for the air. Now, I will hold it to the fire, and you will see what will happen."

In less than half a minute, they saw the card drop off, and the water fall out on the hearth.

"What is the cause of that, papa?" said Louisa.

"The paper is something like a sponge in its nature, that is, full of little pores or holes, the water makes its way into these, and gradually makes room for the air, that crowds the paper off."

The party were now summoned to dinner, and the children went to tell their mother of the last experiment, which pleased them most of all.

CHAPTER III.

EARLY on the following morning did George and Louisa repair to the library, in order to resume those philosophical recreations in which they took so much delight.

"I have been thinking," said Louisa, "that if the atmosphere exerts so much pressure, and has so much weight, it is strange that it should not fall down on the earth."

Mr. Somers replied, "that the air was a peculiar fluid, which from its elastic or springy properties was distinguished by the term of an *elastic* fluid."

Louisa said she understood what a fluid was, for "George had told her, but she did not think she perfectly understood the meaning of the word elastic."

Mr. Somers then blew into a bladder which he had previously provided, and when the

bladder was full of air, bid her try to press it together. When she tried to do so, she perceived the sort of resistance that it made, and after she had squeezed it, felt the force with which it returned to its former shape and form. "This capacity," said Mr. Somers, "which the air has of being reduced to a smaller space by the force you exert, and of filling again the same space as before, is called elasticity."

"But I suppose," said George, "that its own weight causes it to fall towards the earth—what, then, is the reason, as Louisa says, that it does not fall on the ground, like any other body?"

"And so it actually does," replied Mr. Somers. "The lower portion of the atmosphere rests upon the ground, but the strata above it do not fall, because they are supported by the particles beneath them, in the same manner as the water at the surface of a basin

is supported by that at the bottom: the only difference in these two cases arises from the one being an elastic, and the other an inelastic fluid. So that the air, after compression, resumes its original dimensions; and since the atmosphere, by its weight, is always in a state of compression, so is it always endeavoring to expand itself."

"If, then, the weight were diminished," observed Louisa, "the air would become lighter, and I suppose that is the true reason of its being so much lighter in the upper regions."

"Scarcely," replied her father.

"And yet I am quite sure," said Louisa, "that I have lately read an account of the air being so extremely light, upon the top of a high mountain, as to affect the breath, and occasion great uneasiness."

"I do not deny the fact, my dear, I only question your explanation of its cause. Can it not, think you, be accounted for upon some

other principle than that of diminished weight?"

Louisa was unable to suggest any other probable reason.

"The fact, then," said her father, "is simply this: since the air is elastic, or capable of yielding to pressure, so, of course, the lower parts must be more dense, or in a greater degree of compression, than those which are above them. In a pile of fleeces of wool, are not the lower fleeces pressed together by the weight of the superior ones, and do they not lie light and loose in proportion as they approach the uppermost fleece, which receives no external pressure, and is confined merely by the force of its own weight?"

"Clearly," said Louisa.

"Well, then, we will suppose, for example, that the whole column of the atmosphere were divided into a hundred parts, and that each of these parts weighed an ounce; would

not the earth, and all things on its surface, be, in such a case, pressed upon with the whole hundred ounces?"

"No one can doubt that," said George.

"The lowest portion of air," continued Mr. Somers, "would be pressed upon by the ninety-nine ounces above it; the next, by ninety-eight, and so on, until we arrive on the ninety-ninth stratum from the bottom, which would, of course, be subjected to no more than one ounce of pressure on to the weight of the last and highest portion."

The children were perfectly satisfied with this simple explanation, and George inquired "whether, for the same reason, the water at the bottom of the sea must not be very dense, and unlike that we are accustomed to observe on the surface?"

His father, however, corrected this notion by stating, "that water, not being, like air, elastic and compressible, would not suffer

any material diminution in volume, although pressed by the enormous weight of the ocean above."

"But this would not be the case, if we could dig a pit to the centre of the earth," said George; "the air, I suppose, in that case, would be very dense at the bottom."

"The density of the air," replied his father, "would undoubtedly materially increase as we descend; because the air is compressible. It has been calculated that, at the distance of thirty miles below the surface, the air would have the same density as water, and at the depth of forty-two miles that of quicksilver, while at the centre it would probably be more solid than any substance of which we have any idea, for its density would be thousands of millions times greater than that of mercury. At the surface of the earth, however, this pressure of the air is only great enough to

sustain a column of water thirty-three or thirty-four feet high."

"How sustain a column of water?" said Louisa.

"Do you recollect the experiments we tried yesterday?" said her father.

"Certainly, papa," said Louisa, "you mean the experiments you showed us with the burning paper and the tumbler, to make an empty space—a vacuum, I remember you called it, in the tumbler, that we might see whether the water would rise and fill the place which the air had filled."

"Now," said Mr. Somers, "if we had a pipe thirty-three or thirty-four feet long, and if this pipe were filled with water, and the end were open, and it were set in a tub of water, the pressure of the atmosphere on the water in the tub would prevent the water from falling out."

"Pray, papa," said Louisa, "why did you

say that the water would be held up, or sustained, by the pressure of the atmosphere, to thirty-three or thirty-four feet high in the tube? Would it not stay at one or the other of those heights?"

"That is a very sensible question, Louisa. The reason is, that the pressure of the atmosphere is not always the same. In fine weather, it is generally greater than when it rains or snows. The pressure, or as it is sometimes called, the weight of the atmosphere, is less at some times than at others."

"Then," said George, "if we had such a pipe, or tube, we could tell by the rising or falling of the water in the pipe, when the air was lightest, and then we might suppose that the weather was going to change."

"Very true," said his father, "but it would be very difficult to make them so that the rise and fall of the water could be easily seen, because you must go to the top of the house

every time you wanted to consult the barometer. In the next place, frost would turn the water in the tube into ice, and there would be an end to the barometer. Now the ingenious have constructed an instrument for ascertaining the weight of the air, which is not liable to either of these objections. Instead of water, a shining liquor, called quicksilver, or mercury, is made use of, which is more than fourteen times heavier than water. Now, George, if the pipe thirty-three feet long, was filled with quicksilver, do you think that the pressure of the atmosphere would hold up the quicksilver thirty-three feet high?"

"Certainly not," answered George, "because the quicksilver is so much heavier than water."

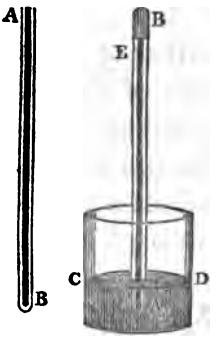
"Very true, George. It has been found by experiment, that the pressure of the atmosphere will sustain a column of mercury about twenty-nine inches high; sometimes it will

sustain a column of only twenty-seven inches; and sometimes a column of thirty, according to the pressure of the atmosphere. Now the tube is always made of glass, so that the mercury may be seen as it rises and falls."

"How long is the tube of the barometer?" said George.

"It is generally about thirty-six inches long; but as the mercury never rises to the top of the tube, there is always an empty space between the top of the mercury and the top of the glass, which allows the mercury to rise and fall, as the pressure of the atmosphere is more or less. But you will understand it more clearly from this figure. A. B. is a glass tube, more than thirty inches in length, open at one end, A, and closed at the other end, B. C. D. is a cistern, containing mercury. The tube A. B. is first placed in an upright position, with the open end upwards, and is

filled with mercury. The finger is then placed over the open end A., which is plunged into the cistern C. D. Upon removing the



finger, therefore, the mercury in the cistern meets the mercury in the tube—so that the atmospheric pressure acting upon the surface F., supports the column E. A., while the surface E. is protected from this pressure."

"All this is rather difficult," said Louisa.

"So it must appear to you at first, my dear,

but when you have seen it often, and talked with your brother about it, you will understand it more clearly."

"I think I understand it already," said Louisa.

"Well, can either of you think of any use that can be made of the barometer, except to foretell the weather?"

George and Louisa were both silent.

"Do you recollect what was said about the density of the air on a high mountain, and in a deep pit?"

"O! certainly, papa," exclaimed Louisa, "it will be much heavier in the pit, than on the mountain, because in the bottom of the pit the air in the pit is added to the air above the pit."

"I believe you understand it. Suppose you took a barometer to the bottom of the pit, do you think the mercury would rise or fall?"

"I think it would rise at the bottom of the pit."

"Right; now if you took it to the top of a high mountain, would it rise or fall?"

"I think it would fall," replied Louisa.

"Why?" said Mr. Somers.

"Because then there would be less weight pressing upon the quicksilver in the cup, and therefore less quicksilver would be pressed up into the tube."

"Very well indeed; I see you remember all I taught you about the pressure of the atmosphere. Now, suppose the pit a hundred feet deep, and the mountain two hundred feet high—which would make three hundred. Suppose that you observe exactly how much the quicksilver falls, when you take it from the bottom of the pit to the top of the mountain. You would have a measure by which you could judge of the whole height and depth."

"I see I should," said Louisa: "I see! I see the use of the barometer, and it is very useful."

"But you do not see all yet," said Mr. Somers. "By marking this you would not only know how much it fell in those three hundred feet, but by dividing it, and making a scale, you might know the same thing afterwards, of any number of feet, or of any height to which you might take the barometer."

"Very ingenious, very convenient," said George and Louisa at the same moment. "Now I understand the use of the barometer."

"I fear," said Mr. Somers, "you will suspect that our amusements are to be changed into lessons, if we continue these illustrations much farther."

"Oh! not at all, papa. Not at all, do go on."

"Then," said he, "George must bring his

pop-gun, and we will have something more amusing."

"But will you have the quill or wooden pop-gun, papa?"

While George was gone for his amusement, Mr. S. reminded Louisa of what he had taught her respecting the elasticity of the air, that is, that it may be forced into a smaller space than it usually occupies, and as soon as the force is removed, it will spring back, and fill its former place.

As George came running into the library, pop, pop, went his gun, and away flew the pellets, to a great distance before him.

"Now," said Mr. Somers, "tell me the origin and nature of the force which enables you to shoot your pellet to so considerable a distance?"

"It depends upon the action of the air," replied George.

"Undoubtedly; but your answer is too ge-

neral; I wished you to state, in precise terms, the changes which the air undergoes upon this occasion. You first ram in your pellet to the farther end of the tube, do you not?"

"To be sure; and then I drive in a second, and on forcing this forward, the first flies out, with prodigious force."

"Very well; now examine what takes place; on propelling forward your second pellet, you condense the air which is enclosed between the two, until its elastic force becomes so great as to overcome the resistance of the first pellet; thus released, the air expands with considerable force, and imparts a rapid motion to the pellet."

"I have frequently heard of the air-gun," said Louisa. "I suppose it depends upon a similar principle."

"It does; and it affords a very striking example of the surprising force which air is capable of exerting when condensed to a consi-

derable degree; for, by means of this instrument, bullets may be propelled with a force very nearly equal to that of gunpowder."

"I feel very curious to learn something more about this air-gun," said George.

"You will best understand it," said Mr. S., "from this figure. B is a reservoir of con-

densed air, which is confined by a nicely constructed little door that is closed by a spring. A is an iron gun-barrel, into which the leaden bullet is put, and rammed down to the lock. C is the trigger of the gun, and when this is pulled it unbends the spring, which of course opens the door, and thus a portion of the condensed air is liberated. This liberated air rushes through an opening in the lock

immediately before the ball, and drives it to the distance of sixty or seventy yards at least. By re-cocking the piece, another discharge may be immediately made, and thus repeated to the amount of fifteen or sixteen times, with a very small hissing noise, which at a distance cannot be heard.

"But how is the condensed air introduced?" asked George.

"By means of a condensing syringe," replied his father, "which I will take another opportunity to explain and exhibit."

CHAPTER IV.

"George," said his father, "bring me a saucer with some hot water, a piece of soap, and a tobacco pipe. I will teach you the art of blowing soap-bubbles."

George immediately brought the necessary implements, and made the lather.

"Now," said Mr. Somers, turning to the eldest of his children, "plunge the bowl of the pipe into the lather."

George obeyed his father's directions, and blowing through the stem, produced a bubble.

"See, see!" cried Louisa, "what a beautiful bubble! but there is a quantity of soap hanging to its under part."

"I will take it off with my finger," said Mr. Somers.

"There it goes," exclaimed George.

"What beautiful colours it displays! as

bright and gaudy as those of the rainbow," observed his sister.

"It has burst," cried George.

"There is another," exclaimed Louisa: "see, it is shaped like an egg! there it goes,

—but I declare, it is now perfectly round!! What can be the reason of its changing its figure?"

"I am glad you have asked that question, because my answer will serve to illustrate an important property of air, and which indeed

is common to all fluids. While the upper part of the bubble was fastened to the bowl of the pipe, its weight being resisted, drew it into an egg-like form; but the instant it was detached, the air contained within the bubble pressed equally in all directions, and the bubble in consequence became perfectly round."

"I do not exactly understand what you mean, by pressing it equally in all directions."

"The expression is surely easily enough understood. Did you not learn, in our conversation of yesterday, that air has weight, and exerts a pressure as much upwards as downwards and sideways? Were not this the case, how could the air in the interior of our bodies counteract the pressure of the atmosphere, or how could the card be kept from falling off from the mouth of the inverted glass? The form of the bubble proves the same fact in a different way; for, had the air in its cavity pressed more in any one direc-

tion than another, the bubble could not have been round."

"What are you musing about," cried Louisa, who had observed the attention of her brother fixed upon the bowl of the tobacco pipe. "I am sure, from your countenance, that something puzzles you."

"You are right. I was just then thinking how it could possibly happen that the bubble should not have a hole in its upper part; for while I am blowing it up, there must of course be a communication between my mouth and its inside, or else how could the air press into it?"

"True," said his father; "but the act of throwing it off from the bowl of the pipe will unite this breach; you will, therefore, perceive that on this account the bubbles will be more safely separated by moving the pipe sideways, than by moving it directly up or down."

"I wish," said George, "that I could discover some method of preventing their bursting so soon, for there is scarcely time to examine them, before they vanish. What can be the cause of their short duration?"

"Consider, my boy, the frailty of their structure, and I think that the shortness of their existence will cease to astonish you; indeed, the wonder is that they should endure so long. The film of which they consist, is inconceivably thin, so that the slightest impulse will be apt to break them, besides which, there is a considerable evaporation going on from their surface, which much also tend to shorten their duration. You must, therefore, seek, from a succession of bubbles, the prolongation of an amusement, which no single one can afford you."

"And could not the evaporation be prevented?" inquired George.

"If the bubble were blown in a glass ves-

sel, and the latter immediately closed after the operation, it would remain for some time: I remember having once preserved a bubble in this manner for a very considerable period."

George, however, did not appear to relish this scheme; as, he said, the great sport arose from watching the movements of the floating bubbles: the boy accordingly determined to pursue the amusement in the usual manner.

During this dialogue, Louisa had succeeded, for the first time, in launching the airy bubble. Imagination always tinges the objects of our first efforts with brilliant tints; no wonder, therefore, that Louisa, with a shout of ecstacy, should have pronounced it to have been the most beautiful bubble she had ever seen; in truth, the sun was shining brightly, and the colors thus produced very justly excited the admiration of all present.

"I cannot understand the cause of these beautiful colours," said Louisa.

Mr. Somers expressed a fear that, in the present state of their knowledge, they would be scarcely able to understand the explanation he should afford them. "But," said he, "I believe you know that a ray of light is divisible into seven colours, and that when a ray passes through certain objects, or is reflected from certain substances, this division is effected and the various colours produced."

"Now, George," said his father, "fetch your squirt, for we have not yet finished our inquiry into the effects of the air's pressure."

The squirt was produced; but it was out of repair; for, on attempting to fill it with water, the instrument entirely failed in the performance of its office.

"I see the defect," said Mr. S., "which a little string will easily remedy."

A piece of string was instantly produced

from that universal depository, the breeches pocket of a school-boy. Mr. Somers said he should bind a portion of it round the end of the piston.

"What do you mean by the piston?" inquired George.

"The rod which moves up and down in the tube; and unless its end fit so exactly as to prevent the admission of air, it is evident that the squirt cannot draw any water. It was for the purpose of making this part fit tightly, that I wound the string, and you will now perceive that the instrument is ready for use: fetch me a basin of water."

George soon produced the water, and on placing it on the ground, requested that he might be allowed to fill the squirt. This he accordingly effected without difficulty, and on pressing down the handle, he projected a stream of water a considerable distance.

"Explain now," said Mr. Somers, "the operation of the squirt.

"As soon as I raised the piston, an empty space was left in the lower part of the cylinder, which I suppose would have remained as a *vacuum*, had not the water rushed into it."

"And why did the water rush into it?"

George hesitated.

"Was it not, think you, owing to the pressure of the atmosphere upon the surface of the water? When you raised the piston, the air above it was also raised, and ultimately driven out by the force of the ascending piston; and since the air could not find any entrance from below as long as the point was under the water, the interior of the squirt would necessarily have remained quite empty, or have been a vacuum, had it not been for the weight of the atmosphere, which, not having any counteracting pressure, drove the water into the tube, and thus filled it: and

which, by pressing down the piston, you again expelled with considerable force."

"Your explanation," cried Louisa, "is so clear and intelligible, that I feel quite confident I could now explain any machine that owes its action to the exhaustion of the air, and the pressure of the atmosphere."

"If that be your belief," said Mr. Somers, "I will not lose a moment in putting your knowledge to the test. George, do you run into the house, and fetch here the kitchen bellows."

The bellows were produced, and Louisa, having been desired by her father to explain the manner in which they received and expelled the air, proceeded as follows: "Upon raising the upper from the under board, the interior space of the bellows is necessarily increased, and immediately supplied with an additional quantity of air, which is driven into it by the pressure of the atmosphere;

when, by pressing down the upper board, it is again expelled through the iron tube or nosle."

"To be sure," said George, "in the same manner that the water was expelled from my squirt, when I pushed down the handle."

"So far you are quite correct," said Mr. Somers; "but you have not yet told us the use of the hole in the under board, and which is covered, as you perceive, with a moveable flap of leather; it is termed a valve, or '*wind-clap.*'"

"That," replied George, "is for the purpose of admitting the air, when we raise up the board."

"Exactly so; and also to prevent the air from passing out again, when you press it down. I wish to direct your attention particularly to this contrivance, because, simple as it may appear, its action will teach you the general nature of a valve. Without it, the operation of filling the bellows with air would have been so tedious as to have destroyed

the utility of the instrument; for the air could, in that case, have only found admission through the nosle, and that, again, would have been attended with the additional disadvantage of drawing smoke and other matter into its cavity; when, however, you raise up the board, the air, by its external pressure, opens the wind-clap inwards, and thus finds an easy entrance for itself; and when you press the board downwards, the air, thus condensed, completely shuts the valve, and its return through that avenue being prevented, it rushes through the tube."

With the simplicity of this invention, the children were much pleased.

Mr. Somers now proposed that they should consider the structure and operation of the pump.

"I suppose," said Louisa, "that the pump raises water in the same manner as the squirt."

"Exactly upon the same principle," repli-

ed her father; but the machinery is a little more complicated, since its object is not to force the water out of the pump at the same end of the pipe at which we draw it in. We will, however, proceed to the stable yard, and examine the pump; and do you, George, provide a piece of chalk, in order that I may make a sketch of some of its principal parts."

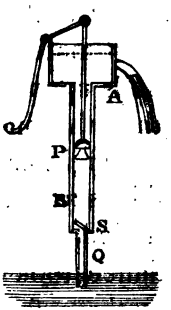
The party immediately proceeded; and, as they walked along, Mr. Somers desired the children to remember that the weight of the atmosphere was estimated to be equal to that of fifteen pounds upon every square inch of surface; and that the moment the water arrived at such a height as to balance that pressure, it could ascend no higher: "you remember," he added, "that the height at which such a balance took place was about thirty-two or thirty-three feet above the surface."

"If that be the case," said Louisa, "the pump, of course, can never raise water from

any well of greater depth than that which you state."

"Not without some additional contrivance, which I shall afterwards explain to you," replied Mr. Somers.

The party had by this time arrived at the pump; its door was opened, and as much of the apparatus exhibited as could be conveniently exposed. Mr. Somers then chalked the annexed sketch upon the stable door.



"Is that a pump?" cried George: "I should certainly never have guessed what you intended to represent."

"It is not a drawing of the outside, my dear, but a representation of the different parts as they would appear, were it possible to cut the pump in halves, from top to bottom, without disturbing any of its arrangements. A drawing of this kind, which is frequently used for the sake of explanation, is termed a *section*."

Mr. Somers here took an apple from his pocket, and having cut it in two, observed that the surfaces thus exposed presented the *sections* of the fruit. This illustration was understood by all present, and Mr. Somers continued, "I have here, then, a section of the common household pump. AB is the cylinder or barrel; P the air-tight piston which moves or works within it, by means of the rod; Q is the suction, or feeding pipe, descending into a well, or any other reservoir; S the valve, or little door, at the bottom of the barrel, covering the top of the feeding pipe;

and there is a similar valve in the piston, both of which, opening upwards, admit the water to rise through them, but prevent its returning. As this part of the apparatus is no less ingenious than it is important, I will sketch the valve, or *clack*, as it is termed by the engineer, on a larger scale."

Their father then chalked the annexed figure; from which its construction was rendered perfectly intelligible to the children.

Mr. Somers proceeded: "When the pump is in a state of inaction, the two valves are closed by their own weight; but, on drawing up the piston P, from the bottom to the top of the barrel, the column of air which rested upon it is raised, and a vacuum is produced between the piston and the lower valve, S;

the air beneath this valve, which is immediately over the surface of the water, consequently expands, and forces its way through it; the water then ascends into the pump. A few strokes of the handle totally exclude the air from the body of the pump, and fill it with water; which, having passed through both valves, runs out at the spout."

"I understand how water may be thus raised to the elevation of thirty-two feet, but I have yet to learn the manner in which it can raise it above that distance," said Louisa.

"It is undoubtedly true, that, if the distance from the surface of the water to the valve in the piston, exceed thirty-two feet, water can never be forced into the barrel; but you will readily perceive that, when once the water has passed the piston valve, it is no longer the pressure of the air which causes it to ascend; after that period, it is raised by lifting it up, as you would raise it in a bucket, of

which the piston formed the bottom; and water having been so raised, it cannot fall back again in consequence of the valve, which is kept closed by its pressure. All, therefore, that is necessary, is to keep the working barrel within the limits of atmospheric pressure; we have then only to fix a continued straight pipe to the top of the barrel, and to lengthen the piston rod in the same proportion, and the water will continue to rise at each successive stroke of the pump, until at length it will flow over the top of the pipe, or through a spout inserted in any part of its side. The common pump, therefore, is properly called the *sucking* and *lifting pump*."

The party expressed themselves fully satisfied; and George inquired who invented the machine.

"It is an instrument of great antiquity," replied his father; "its invention is generally ascribed to Ctesbes of Alexandria, who lived

about one hundred and twenty years before Christ; but the principle of its action was not understood for ages after its invention. The ancients entertained a belief that 'Nature *abhorred* a vacuum;' and they imagined that when the piston ascended, the water immediately rushed forward to prevent the occurrence of this much-dreaded vacuum. In the seventeenth century a pump was constructed at Florence, by which it was attempted to raise water from a well to a very considerable altitude, but it was found that no exertion of this machine could be made to raise it above thirty-two feet from its level. This unexpected embarrassment greatly puzzled the engineer, until Galileo suggested that the pressure on the water below must cause its ascent into the pump, and that according to his theory, when it had risen thirty-two feet, its pressure became equivalent to that of the atmosphere, and could, therefore, not rise any higher; and

as they did not, at that time, understand the construction of the piston valve, the design was abandoned."

"There is another method," continued Mr. Somers, "by which liquids are raised, and then made to flow off in another direction. Can you think of any instrument, George, which can be employed for that purpose."

George was unable to think of any, and was much astonished on being told that it was the syphon.

"I understand, papa," said he, "how the water will rise to the top of the syphon, if the air is first exhausted."

"And can you think of no way to exhaust the air?"

George could imagine none, except by a piston, which, his father informed him, would be difficult and laborious.

Mr. Somers then took a bent tube, or syphon, and holding the open end upwards, fil-

led it with water. "You see," said he, "that it can contain no air."

George and Louisa assented.

Mr. Somers then closed both ends of the syphon with his thumbs, and turning the syphon down, put one leg in the reservoir that contained the water drawn from the pump, and the other leg outside of the reservoir. The water immediately began to flow from the reservoir through the syphon.

"I am sure," said George, "I understand it—I am sure I understand it. As the water in the leg outside of the reservoir falls to the ground, a vacuum is created in the top of the tube, and the atmosphere pressing on the water in the reservoir, forces it up as fast as a vacant space is produced."

"Very well," said his father, "you have explained a principle in philosophy on which depends many interesting amusements, and many remarkable appearances in nature.

You observe that the water continues to flow from the syphon, and it would do so if left alone, from the cause which you explained, till the water was all drawn off. But you must be careful to have the leg which is inserted in the reservoir shorter than the other, for a reason which I will explain hereafter. In this way, all the liquor contained in a cask may be drawn off by the bung-hole, or be transferred from one cask to another."

Mr. Somers then ordered a cask filled with water, which he told George he might amuse himself in drawing off at his leisure.

On their way into the house, Mr. Somers continued his conversation respecting the use of the syphon. "The ingenious," continued he, "have often disguised it so as to produce many entertaining and apparently surprising effects. Thus, it is often concealed in the handle of a cup, which will contain the liquor poured into it until it has reached a certain

height, when it will begin to run out, and continue to do so, till the vessel is emptied. Here is a cup with a figure standing in the centre, which they call a Tantalus. It is so

called from the fable of Tantalus, thus described by Homer:

'Then Tantalus along the Stygian bounds,
Pours out deep groans, (with groans all Styx abounds,)
Even in the circling floods refreshment craves,
And pines in thirst amidst a sea of waves;
And when the water to his lips applies,
Back from his lips the treacherous water flies.
Above, beneath, around his treacherous head,
Trees of all kinds delicious fruitage spread.
There figs high-dyed in purple hue disclose,
Green looks the olive, the pomegranate glows,

There dangling pears exalted scents unfold,
And yellow apples ripen into gold:
The fruit he strives to seize, but blasts arise,
Toss it on high, and whirl it to the skies.'"

"How beautiful," exclaimed Louisa.

"But, papa, do not forget the explanation of the cup," said George, impatient to understant the secret.

Mr. Somers then took a pitcher of water, and began to pour it into the cup.

"You see," said he, "the water I put into the cup remains there—now it has nearly reached the lips of the figure."

"See, see, father," said Louisa, "it does not rise any farther."

"The reason," said Mr. Somers, "why it does not rise, I suppose you understand."

"Because there is a syphon concealed somewhere," said George.

"A reasonable conjecture," said his father.

"The water has all disappeared, papa," said Louisa.

"The mystery is all explained in a few

words," said Mr. Somers. "Concealed within the figure, or Tantalus, is a syphon, the shorter leg of which opens into the cup, while the longest leg descends through the bottom into a reservoir below."

"How beautiful," exclaimed the delighted children.

"Sometimes," said Mr. Somers, "a bird has been placed by the side of a basin, into which the water from a fountain falls, and the bird drinks up all the water that falls into the basin. The construction of the machine is as follows: Let A be the spout," said he, mark-

ing the figure with his pencil on a piece of paper, "B the basin, and E. the bird. The

neck of the bird, you perceive, is bent, and as it is hollow, acts evidently as a syphon, so that as soon as the water reaches the top of its neck, it begins to flow off trough a tube, which passes down one of its legs to the ground. There are a great number of these amusing contrivances, which depend for action upon the principle of the syphon, but their explanation must be deferred to another time—and I fear you are already fatigued."

"Not at all, papa," said Louisa, "we are not fatigued in the least."

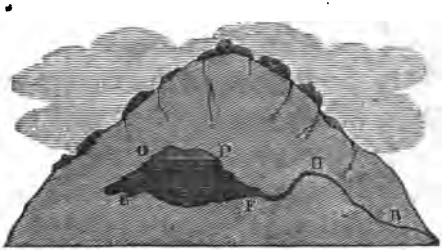
"Then," said he, "I will explain to you a wonderful fact in nature, but you must give very good attention, for I shall be obliged to illustrate it by a drawing."

"I am sure," said she, "we will try."

"I had reference to what are called intermitting springs."

"Pray, papa," said Louisa, "what does intermitting mean?"

"Intermitting, my dear," replied her father, "means subject to interruptions, and intermitting springs are those which flow freely for a time, and then cease for a certain interval, after which they flow again. This cut," said he, opening Adams' Lectures at the subject 'intermitting springs,' "this cut repre-



sents the section of a hill. The dark place in the middle, between the letters O P E F, is a cavity, or hollow in the interior of the hill; from the bottom of this there is an outlet, F H B, shaped as you see like a syphon."

"Oh! yes, papa," said George, "I see how

it operates; the water does not begin to flow off until it has risen in the hollow to the top of the outlet, and then it will begin to flow off through the outlet H B."

"And how long will it continue to flow?" asked Mr. Somers.

George instantly replied, "as long as there was any water in the hollow."

"Yes," said Mr. Somers, "if the syphon reaches to the bottom of the cavern, when it will cease, if it is not supplied with more water, and will not flow again, until the hollow is filled to the top of the syphon. Many instances of this kind," continued Mr. Somers, "occur in nature. The author of the 'Description of Switzerland,' speaks of such a spring in the Canton of Berne. It begins to flow early in the month of May; and the simple peasants in the neighborhood firmly believe that the Deity sends them this spring every year for the use of their cattle, which

about that period they drive to the mountains. The annual re-appearance of this fountain on the approach of spring, may be easily explained,—for at this period masses of ice are melted on the mountains, which fill a cavity concealed within some elevation, which causes the fountain in question to flow. It is now time to conclude your lesson; tomorrow I hope we shall be able to enter upon the subject of the kite."

CHAPTER V.

The children were summoned into the library, and informed by their father, that he was at leisure to explain the philosophy of the kite; a subject with which George had repeatedly expressed some impatience to become acquainted.

"It is a beautiful day," exclaimed the boy, joyously; "and there is such a delightful breeze, that I should really call it a complete *kite-day*."

"Gently, my fine fellow," replied Mr. Somers; "the bird must be fledged, ere it can fly. We have not, as yet, any kite; for you know that the one you possess is shattered beyond the possibility of repair."

"True, papa; but could not Robert just step into the village and buy one? I saw se-

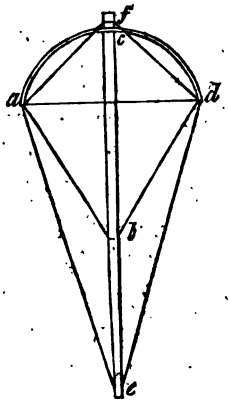
veral kites in the shop of Peg Robson yesterday."

"I do not doubt it, my boy; but the kites which are to be found in the toy-shops are made to sell, rather than to fly; and to *raise the wind*, for the benefit of the vender, rather than to be raised *by it*, for the amusement of the purchaser: we must, therefore, construct one for ourselves; and see, I have, accordingly, prepared all the necessary materials for the purpose. I have here, as you perceive, a straight lath of pine, about three quarters of an inch wide, and less than a quarter of an inch thick, and about four feet in length; this is quite ready for forming the *back-bone* of the kite; and now for the bow. The cooper has complied with my directions, and sent an unbent hoop, as free as possible from knots; you observe that it is about the same length as the lath, but it will be necessary to pare it

down a little at each end, in order to make it bend more readily to the required shape."

This having been accomplished, Mr. Somers proceeded to form the framework of the kite in the following manner. He first ascertained the central point of the hoop, by balancing it on his fore-finger; he then affixed that point, by means of string, to the lath, at *c*, about an inch and a half from its upper extremity; a notch was next cut in each end of the hoop, or bow, *a d;* having fixed the string in the notch *a*, he drew it through another, *e*, previously cut in the bottom of the lath, and carried it to the opposite end of the bow, *d;* the skeleton now presented the usual form of the kite. The next point, therefore, was to ascertain whether the two sides of the bow were in equilibrio, which he determined by balancing the lath on the finger, and observing whether it remained horizontal, or dipped on either side. This adjustment having

been accomplished, Mr. Somers next continued the string from *d* across the skeleton to the opposite notch *a*, giving it one turn round the



lath in its way; from *a* it was carried to *f*, and wound round the top of the lath, and then again fastened at *d*; from *d* it was extended rather more than midway down the lath, and having been secured at *b*, was finally carried to, and secured in the notch *a*. The frame-

work was now pronounced by Mr. Somers to be complete.

The next part of the process was to cover it with paper. Mr. Somers observed, that the best kind which could be employed for this purpose was that known amongst stationers by the name of *fan paper*, so called from its being manufactured for the use of the fan-makers; its merit, he said, depended upon the size of its sheets, as well as upon the thinness and firmness of its texture; this, however, was not at hand, he was therefore obliged to rest satisfied with its best substitute, viz. folio sheets of large thin post.

The party now went "ding dong" to work; paper, paste, and scissors were immediately put in requisition. Sheets of paper were laid smooth on the table, and so arranged that each sheet overlapped its neighbour about half an inch. The skeleton of the kite was then placed upon them, and the paper was

cut to its figure; a margin, of about three quarters of an inch, having been left around it, except over the bow, where the margin was extended to an inch in width; this arrangement was for the purpose of allowing the paper to turn over the framework, when pasted to it. This part of the work having been completed, and a sufficient time allowed for the drying of the paste, Mr. Somors proceeded to fix the string usually termed the *belly-band;* for this purpose two holes were drilled through the lath, at equal distances from its edges; the upper one about a fifth part of the length of the kite from the top, the lower hole rather more than the same distance above its extremity.

The last, and by far the most important point, was to make the loop in the *belly-band.* If the kite be accurately constructed, its proper place may be easily found by extending the band right and left, on the surface of the

kite, and then marking the string at a point which lies in a line drawn from one end of the bow to the other; the loop must be made a little above such a point. If the kite be now suspended by this loop, the two ends of the bow ought to preserve a balance, and the lower extremity should dip below the upper part of the kite.

As Louisa observed the extreme care with which her father adjusted this part of the machine, she inquired into its use.

"I was myself about to put the same question." said her mother: "for its adjustment would appear to require as much accuracy as that of the sash of a girl of sixteen,"

Mr. Somers informed them, they would hereafter find that the steady ascent of the kite into the air entirely depended upon such accuracy. "Have you not seen, George," asked he, "a kite rise sideways, or *plunge*, as it is called?"

George said he had often experienced that difficulty at school, but that he had attributed it to some defect in the tail.

"An error in the construction of the tial may, certainly, be occasionally the cause of such an accident, but it is more generally referable to an improper position of the loop; if the kite *plunges*, you may conclude that this loop is placed too high; and should it whirl round in the air, you may infer that it is too low."

The next thing to be made was the tail.

Mrs. Somers and her daughter, with George, were, therefore, placed round the table, for the purpose of carrying this project into effect, by a suitable division of labor. It was arranged that Mrs. Somers should cut the paper, George fold it, and Mr. Somers tie it on the string.

"How long ought the tail to be?" asked George.

"And at what distances are they to be placed from each other on the string?" said Mrs. Somers.

"I will answer all your queries," replied the father, "by giving you a dissertation upon this part of our machine.

"The tail should never be less than twelve, and should it even amount to twenty times the length of the kite, its appearance in the air will be more graceful; this, however, must be regulated by the weight of the string, and by the length and thickness of the pieces of paper of which the tail is composed. The length of each ought to be about three inches and a quarter, and an inch and a half in breadth, and it should be folded four times, lengthwise: each of these *bobs*, as they are called, must be placed at regular intervals of three inches."

"And with respect to the size of the wings?" asked George.

"I should not recommend any wings; if the kite be well made, there cannot be any advantage from such appendages. Having now answered your several questions, let us proceed with our work."

"But where is the paper?" asked Mrs. Somers.

"Apropos," answered her husband; "the box in which the toys were packed contains a quantity that will answer our purpose."

The box was accordingly placed on the table, containing a fragment of almost every description of literary and scientific works.

"The market," observed Mr. Somers, "is supplied with waste paper from the catacombs of the Booksellers—which may be truly said to 'level all earthly distinctions.' Without intending any offence by a pun, what a *tale* will this box unfold! I never open a magazine of this waste paper, without feeling a deep sympathy for the melancholy fate of

authors: to see the strange transmigrations, and vile purposes, to which their works are destined, is really heart-rending. That the *lights* of science should be consigned to the tallow-chandler! the works of the moralist, so well calculated to *purify* the world, to the soap-seller! that such a book as 'Laennec on the *Chest*,' with Dr. Forbes's valuable *Cases* in the bargain, should be *packed* off to the trunk-makers! are events which cannot fail to furnish food for melancholy reflection. Nay, more, I have myself actually received a quantity of uric acid in a review of Dr. Thomas's Chemistry! and I only yesterday learned, with horror, that a piece of fat bacon was positively wrapped up in a page of 'Paris on Diet;' while a Goshen cheese came encased in Kitchener's 'Chart of the Moon.'"

"I also remember," said Mrs. Somers, "you lately received a work on the abolition of slavery in the fragments of a tract on 'the

Progress of Cant,' and a copy of a distinguished politician's orations, in an Act of 'Much Ado about nothing.'

"If you compose the tail of your kite with these papers," continued she, "it will certainly vie with that of Scriblerius himself; you will have a knot of divinity,—a knot of physic,—a knot of logic,—a knot of philosophy,—a knot of poetry,—and a knot of history."

"Never mind, my dear; you well know that I am no gamester, but yet, upon this occasion, I will wager, that I shall be able to discover in each page, with which you may present me, some apposite allusion to the *tail* of which it is to form a part."

"Apposite allusion!! impossible; as well might you attempt to connect the scattered leaves of the Sibyl; for example, here is an epitome of the Roman History."

"Very well," said Mr. Somers, "and pray is not that cur*tail?*"

"Here," said she, "is a list of the prices of some newly published works."

"That," replied her husband, "is re*tail;* pray proceed."

"We have next, I perceive, a prospectus for publishing all the speeches in the late parliament."

"That is de*tail.*"

Here the whole party were thrown into a continued fit of laughter. As soon as tranquility was restored, Mrs. Somers again dipped her hand into the box, and drew forth the fragments of a work on Real Property.

"That," said Mr. Somers, "is en*tail;* pray, *cut it off*, and give it to me."

"We have here," continued the lady, "the Memoirs of an Italian Bandit."

"Then prepare him for his fate; I have a noose quite ready for his reception."

"Here is a poem, entitled Waterloo."

"I will patronize it," said her husband;

"and I warrant you that, under my auspices, the muse will soar to a greater height than she ever could otherwise have attained."

Thus did Mr. and Mrs. Somers proceed; the one cutting paper, the other cutting jokes; nor did the former cease stringing puns, until he had finished stringing the tail.

"I must now conclude by making a knot that shall not be in danger of becoming untied in the breeze," said Mr. Somers; "but stop, stop one moment; I still require one more piece of paper to complete my task, and let it be double."

"Here then it a piece of paper, which, from its texture, appears to be well adapted to your purpose. Let me see what it is. I declare, it is the title page of an Essay on Matrimony."

"Capital!" cried her husband; "a strange coincidence, truly; you have, indeed, furnished me with a knot that cannot be easily unti-

ed, however stiff may be the breeze; hand it over to me, for it will afford a very legitimate finish, and is generally the conclusion of every *tale*."

The party, shortly after this discussion, separated: Mr. Somers retired to his own room, and the children ran into the garden to enjoy their rural sports.

CHAPTER VI.

On the following day, before the wings of the lark had brushed away the morning dew, had George and his sister, buoyant with expectation, descended into the garden, in order to ascertain the state of the weather, and the direction of the wind; but the sky was sad and calm, not a breath disturbed the susceptible leaves of the aspen; all was repose—"a dread repose."

"No kite-day this," sighed George, with a countenance as lowering as the morning clouds.

"Have patience," said Louisa; "the wind may yet rise, it is only just six o'clock."

Thus did the minds of the children continue to hover between hope and despair, until after breakfast, when they determined to seek the gardener, and hold a grave consultation

with that acknowledged judge of the elements; he told them that showers might be expected, but he thought it probable that the wind might rise after mid-day. "I will, however," said he, "consult my oracle, after which I shall be able to give you a satisfactory opinion." So saying, he left them; and on his return, observed that as "the *African marigold* continued shut after seven o'clock in the morning, he had thought there would be rain; but," he added, that "upon inspecting the *poor man's weather-glass*, the *red pimpernell*, two hours ago, he had found it open, from which he concluded that the day would be fine."

"There, Louisa, it will be a fine day, after all," exclaimed her delighted brother.

"No, indeed," continued the gardener; "on returning just now to the flower, which never deceives us, I found it had closed itself, so that rain is inevitable."

Nor was this opinion erroneous; for before the brother and sister could reach the house, the heavy clouds began to discharge their watery burthens, and the rain continued in one incessant shower for more than two hours; it then gradually abated, and Phœbus cast a sly glance from behind a dark cloud, and illuminated the spot upon which they were standing. In short, after the lapse of half an hour, the sun broke through the gloom, and a brisk gale followed; the countenances of the children sympathised with the face of the heavens, and the expression of hope lighted them up, in proportion as the sun illuminated the departing clouds with its radiance.

"It is now quite fair, papa," cried George, in a voice of triumph, "and there is a most delightful wind; shall we now proceed at once to the common?"

"Presently," answered his father, "the ground is yet extremely wet."

In the course of an hour this objection had been removed, and the party prepared to set off on their kite-flying expedition.

"Bring me the kite, and let me sling it properly over George's shoulder," said Mr. Somers.

"I will carry the string," exclaimed Louisa; "how nicely it is wound round the stick."

As the party walked forwards, Mr. Somers asked George whether he knew from whence the name of the *kite* originated.

"A kite is a bird of prey," answered the boy, "which soars to a great height; and, from remaining stationary in the air, was, I suppose, thought to resemble the paper kite."

"That is a very good explanation," said his father; "or it may, perhaps, have derived its name from the circumstance of its having been originally constructed in the shape of a bird of this description. In China, the flying of kites is much more practised than in this

country; and I understand that their shape is always that of some bird. In the London toy-shops you may constantly meet with them in such forms, as well as in many other fantastic shapes," continued Mr. Somers. "I remember to have seen, some years ago, a kite which resembled a man. It was made of linen cloth, cut, and painted for the purpose, and stretched on a light frame, so constucted as to resemble the outline of the human figure. It stood upright, and was dressed in a sort of jacket. Its arms were disposed like handles on each side of its body, and its head being covered with a cap terminating in an angle, favored the ascent of the machine, which was twelve feet in height; but to render it easier to be transported, it could be folded double, by means of hinges adapted to the frame. The person who directed this kind of kite was able to raise it, though the weather was calm, to the height of nearly five hundred feet;

and when once raised, he maintained it in the air by giving only a slight motion to the string. The figure, by these means, acquired a kind of libation, like that of a man skating on ice. The illusion occasioned by this spectacle did not fail, as you may readily suppose, to attract a great number of spectators."

"I believe, however," observed Mrs. Somers, "that the figure commonly adopted, is the one best calculated for the purpose."

"Undoubtedly," replied Mr. Somers, "and for obvious reasons; the crookedness of the bow enables it to escape the resistance of the air, as it rises; which after having struck, it slides off, just as the current is more effectually turned aside by the gently curved prow, than by that which has a sharp outline; for the same reason, the mast of a ship is more easily drawn through the water with its broad, than with its narrow end, foremost; for although the first resistance is, no doubt, grea-

ter in the former case, yet the water, heaped, as it were, on the front, is made to stream off, and therefore does not hang on the sides of the mast, as it would in the latter case. This shape of the kite, moreover, presents the largest surface at the point upon which the wind can act with the greatest effect, while the whole is lightened by the removal of parts that would obstruct its action. The tail has also a greater control over a figure of such a description."

"I wonder," cried George, "who invented the kite."

"In that," answered Mr. Somers, "I am unable to furnish you with any satisfactory information. The pastime appears to have been of very ancient date in China, and was, probably, first imported into Europe from that country."

"At what period do you suppose?"

"Strutt, who was very assiduous and cor-

rect in all his antiquarian researches, was of opinion that its introduction into England could not be dated farther back than a hundred and fifty years."

The party had, by this time, reached the heath; the weather was favorable; and the kite impatiently fluttered in the breeze, while George was eagerly engaged in unwinding its streaming tail, and preparing the paper machine for ascent.

"Is the string fixed to the belly-band?" asked Mr. Somers.

"All is ready," repled George; "if you will hold it up, I will run with it against the wind."

"There is not the least occasion to raise the kite from the ground," observed Mr. Somers; "let its points rest on the grass, and place its tail in a straight line in front of it; I warrant you it will rise, as soon as you begin to run."

George immediately set off, and the kite rose majestically into the air.

"Give it string—give it string—gently, gently—now stop; there is no occasion for your running any farther, but let out the cord as long as the kite carries it off so vigorously, and keeps it fully stretched, but wind it up the moment it grows loose.

"It is rising very fast," cried the breathless boy, "but the string burns my hand as it passes through it; I shall not be able to endure the heat."

"Be patient, and let it pass more slowly; put on your glove," said his father.

"What is it that produces so much heat?" inquired Louisa.

"The friction of the string," replied her father. "Do you not know that carriages frequently catch fire from the friction of their wheels, unless it is prevented by the application of grease?"

"Yes," said George; "and I have heard that the natives of some countries kindle their fires by rubbing pieces of wood together."

"The original inhabitants of the new world," observed his father, "throughout the whole extent from Patagonia to Greenland, procured fire by rubbing pieces of hard dry wood against each other until they emitted sparks, or burst into flame; some of the people to the north of California produced the same effect by inserting a kind of pivot in the hole of a very thick plank, and causing it to revolve with extreme rapidity; the same principle will explain how immense forests can have been consumed; for it is evident, that the violent friction of the branches against each other, from the agitation of the wind, would be fully adequate to the production of such an effect.

"You have also an excellent example of the effect of friction in producing heat," continued Mr. Somers, "in the history of the whale fishery; for in harpooning the fish, unless the sailors observe the greatest caution in letting out the rope, its friction upon the side of their boat will be sure to set it on fire."

"And how do they manage it?" asked Louisa.

"As soon as the whale makes off, after having been wounded, it draws out the line or cord of the harpoon, which is coiled up in the boat, with very considerable velocity. In order, therefore to prevent any accident from the violence of this motion, one man is stationed with an axe to cut it asunder, if it should become entangled: while another, with a mop, is constantly cooling with water the channel through which it passes."

"The kite is now at a considerable height,"

observed George; "but look at the string, how bent it is! I have repeatedly endeavored to pull it straight but without success."

"How could you have expected to succeed in the attempt? Consider the weight of such a long line of string."

"Then it is not the pressure of the atmosphere which gives it that curved form?"

"Assuredly not; have you so soon forgotten that the air presses equally in all directions, and would therefore tend to straighten, as much as to give a curved direction to the string. But, as you now appear to have let out the whole of your string, suppose you allow the kite to enjoy its airing, while we proceed to consider the philosophy of its ascent, and the nature and direction of those forces by which it is effected."

"The kite pulls so amazing hard," cried George, "that unless I fix the string securely

round the tree, we shall run the chance of losing it."

"I am well aware of the force it exerts,"

replied his father. "Dr. Franklin has said, that with a good kite, a man unable to swim might be sustained in the water, so as to pass from Dover to Calais; but I agree with him

in thinking, that a packet would be a much safer, as well as a pleasanter mode of conveyance."

"We have lately heard of a person having travelled many miles along the road in a carriage drawn by two kites," said Mr. Somers, "and as it would be difficult to manage a single kite at any considerable altitude, the force was obtained by two at a less elevation. Can you tell me, George, what advantage is gained by your running with the kite?"

"I suppose that you thus obtain more force from the wind."

"Certainly. By running with your kite against the wind, you strike the air, and thus produce a reaction, which is equal to the force of the blow given to it. When the wind is high, and its action is not interrupted by surrounding objects, there cannot exist any necessity for such an expedient.

"The principle is the same as that which

enables the bird to rise into the air by flapping its wings," continued he.

"Does the kite then rise in the air from the same causes that enable a bird to fly?" asked George,

"We are not, at present, considering the ascent of the kite, but the advantage which is obtained by running with it; this latter, undoubtedly, depends upon the same principle as that which enables the bird to rise, by the motion of its wings; that is, whenever one body opposes another, the second body opposes the first, with equal force, in an opposite direction. If, then, the bird strikes the air below it with a force which is equal to its weight, then must there be a reaction of the air, upwards, exactly equal to it; and the bird being acted upon by two equal forces in opposite directions, will, necessarily, rest between them."

"That is clear enough; but the bird *rises*," answered George.

"Because the force of the stroke is *greater* than the weight of the bird, and it therefore rises with the *difference* of these two forces; were the stroke *less* than its weight, then would it sink with the difference. Suppose, for example, a bird weighs *twelve* ounces, and it strikes the air with a force equal to *sixteen*, is it not clear that it must rise with a force equal to *four?* and is it not evident that if it strikes the air with a force equal only to *eight*, that it must sink with a force equal to *four?*"

"I understand it perfectly; flying appears to be a very simple process; it would, surely, be an easy matter to contrive some sort of flapper, by which we might all be able to rise into the air," said George.

"Your opinion, my dear boy, is by no means singular; hundreds have entertained the same belief before you; and so confident was the

famous Bishop Wilkins, that he declared it to be his conviction, that in future ages, it will be as usual to hear a man call for his wings, as it is now to call for his boots."

"I do not see the difficulty," exclaimed George.

"The weight of our bodies is so great, that we have not sufficient muscular strength to impart a blow to the air that shall be equal to it. Now are you satisfied?" said his father.

"I am perfectly satisfied, if such be the case, that we can never hope to fly. But you have not yet told us any thing about the tail of the kite; I suppose, however, that it acts like the rudder of a ship, or the tail of a bird."

"Before I answer that question, let me inform you that the tail of a bird has not the least resemblance, in its actions or uses, to the rudder of a ship."

"I always thought," said George, with

some surprise, "that the bird was enabled to direct the course of its flight by the motion of its tail."

"That is a common, but a very erroneous opinion," replied his father: "the tail cannot perform the office of a rudder, since it never changes its situation with the direction of the bird, as the rudder does with that of the ship. Its principal use seems to be to keep its body poised, and upright."

"How, then, is the bird enabled to alter the course of its flight?" asked Louisa.

"It can easily turn, either to the right or left," answered Mr. Somers, "by flapping the opposite wing with increased force, just as a boat is turned about to the right, by a brisk application of the left oar."

"But you have not yet answered George's question, papa,—'Of what use is the tail of the kite?' Does it assist its ascent, or is it merely for ornament?"

"In the first place, it keeps the head of the kite to the wind; and, in the next, it lowers its centre of gravity, and throws it towards its extremity, which not only prevents the chance of the machine being upset in the air, but so poises and regulates the position of the kite, as to maintain the angle which it is necessary for the string to make with the surface of the earth."

George here interrupted the dialogue, by expressing a regret that he should have been provided with so small a quantity of cord.

"I do not believe, my dear boy, that any advantage could be gained by an additional quantity of string," said his father.

"Is there, then, any reason why the kite should not ascend, even above the clouds, provided that my string were sufficiently long and strong?"

"Yes, indeed, is there a most unanswerable reason. Remember that the kite is made to

rise by the operation of two forces; the one afforded by the wind, the other by the action of the string; now it is quite evident that, when the weight of the string, added to that of the kite itself, becomes equal to the force of the wind, acting upon the surface of the machine, a general balance of force will be established, and the kite can no longer continue to ascend."

"Will it, then, remain stationary under these circumstances?" asked Louisa.

"It must do so, unless the force of the wind should abate."

"But if the twine should snap?" said George.

"Then one of these three forces would be withdrawn, and the kite would no longer be sustained."

"I trust that such an accident is not likely to happen; but if it should, we could easily recover the kite, that is one good thing; for

it is hovering over the open field at the end of the meadow."

"If you imagine that the kite, under such circumstances, would fall upon the spot directly under it, you are terribly deceived: recollect that, if the string should snap, the kite would be abandoned to two forces, those of the wind, and its own weight; and you will perceive that, under such circumstances, it could not obey either of them, but would fall in an intermediate direction."

"Has the kite ever been applied to any useful purposes?" asked George.

"Certainly," answered his father. "It was by means of the kite that Dr. Franklin was enabled to demonstrate the identity of electricity and the cause of lightning, and thus to disclose one of the most awful mysteries of nature."

"Pray do tell us something about this electrical kite, papa," said Louisa.

"Not at present, my love; it would divert us too much from the subjects in which we are engaged: at some future period I shall have much pleasure in introducing you into these fairy regions of philosophy."

"I just now remember reading," said Louisa, "something about a kite and Pompey's pillar."

"I am glad that you have reminded me of that story," replied Mr. Somers: "I will relate it to you. Some English sailors laid a wager, that they would drink a bowl of punch on the summit of Pompey's pillar. Now, that pillar is almost a hundred feet high, and it is quite smooth, so that there was no way of climbing to the top, even for sailors, who are such experienced climbers; so they flew their kite exactly over the pillar, and when it came down on the opposite side, the string lay across the top of the capital. By means of this string, they pulled a small rope over, and

by this a larger one, that was able to bear the weight of a man; a pully was then fastened to the end of the large rope, and drawn close up to the upper edge of the capital; and then, you perceive, they could easily hoist each other up. They did more, for they hoisted the English flag on the top, and then drank the bowl of punch, and won the wager. But it is time to return to the village; after dinner I will take an opportunity of showing you some experiments in illustration of the nature of wind."

It was not until the evening that George and his sister requested their father to fulfil the promise he had made them in the morning.

"You told us," said Louisa, "that you would give us some information about the wind; the subject has been puzzling me ever since, for I cannot make out the cause of it."

"Wind, my love, is nothing more than air

in motion; and is produced by a large volume of it flowing in a current, or stream, from one place or region, to another, and with different velocities."

"And what can produce these currents?" asked George.

"After the explanation of the action of the pump, I do not think I shall have much difficulty in making you understand the nature of the operations by which wind is occasioned. Suppose a partial vacuum should be formed in any region, would not the neighboring air immediately rush in to supply the deficiency and restore the balance?"

"Undoubtedly; from the pressure of the air behind it.

"Heat," continued Mr. Somers, "will produce a partial vacuum, by rarefying the air, and thus rendering it lighter; in consequence of which, it will ascend, and the colder air will rush in to supply its place."

"I do not exactly see why the rarefied air should ascend," observed Louisa.

"In the first place, to prove the fact that heated air does actually ascend, we have only to observe the direction of smoke, as it issues from the chimney; this consists of minute particles of fuel carried up by a current of heated air from the fire below; and, as soon as this current is cooled by mixing with that of the atmosphere, the minute particles of coal fall, and produce the small black flakes which render the air, and every thing in contact with it, so dirty in a populous city."

"But I want to know, papa, what it is which causes the hot air to ascend?"

"The greater weight of the cold air above it, which gets, as it were, beneath the lighter air, and obliges it to rise; just in the same way as a piece of cork, at the bottom of an empty vessel, is made to rise to the surface of the water which may be poured into it."

"Now I understand it; pray, therefore, proceed with your account of the wind. You have just said that heat rarefies the air, and causes it to ascend."

"And thus produces a current of air, or a *wind*."

"Is heat, then, the cause of wind, papa?" asked George.

"It is one great cause; but there are, probably, several others; I will, however, exemplify this subject by an experiment."

So saying, Mr. Somers produced a water-plate, a large dish, and a jug filled with cold water. The bell was rung, and the servant entered with a tea-kettle of boiling water.

The large dish was then filled with the cold, and the water-plate with the boiling fluid.

"Let this large dish represent the ocean," said Mr. Somers, "and this water-plate which I will now place in its centre, an island in that ocean; for the land, from receiving the

rays of the sun, will be more heated than the water, and will consequently rarefy the air above it. Now, George, light me the wax taper."

"I have done so."

"Then now blot it out."

"I cannot imagine what you are about, papa;—'Light the candle, and then blow, it out!'—but it still smokes, shall I put the extinguisher over it?"

"By no means; give it to me, and observe what will happen when I carry it round the edges of the dish."

"The smoke goes to the centre," exclaimed George.

"Showing, thereby, the existence of a current towards the water-plate, or island; in consequence of the air above it having been heated, and therefore rarefied. This explains, in a very satisfactory manner, a fact which may be constantly observed in our own cli-

mate, viz. a gentle breeze blowing from the sea to the land in the heat of the day. Upon the same principle it is, that most of the winds in different parts of the globe may be readily accounted for."

"I suppose," said George, "that the air must rush with great velocity, in order to produce wind."

"A very general error prevails upon this subject," replied his father; "the rate of motion has been greatly exaggerated. In a brisk gale, even, the wind does not travel with such velocity but that it may be easily traced by the eye, and the sailor is able to watch its progress by the ripple which it produces on the sea."

"Has then the rate of this motion ever been estimated?" asked Louisa.

"When its velocity is about two miles per hour, it is only just perceptible. In a high

wind, the air travels thirty or forty miles in the same period.

"In a storm, its rate has been computed as being from sixty to eighty miles. It has also been ascertained, by experiment, that the air, as it rushes from a pair of blacksmith's bellows, has not a velocity above that of five and forty miles in the hour."

"At what rate should you think the air travelled this morning, when we flew the kite?" inquired Louisa.

"I should think at about five miles an hour, for it was a pleasant but gentle breeze."

CHAPTER VII.

On the following morning Mr. Somers found his children on the terrace busily engaged in the business of shuttlecock."

"Papa," exclaimed George, "I have been considering whether there is any phylosophy in the game of shuttlecock.

"There is a circumstance connected with its flight," replied his father, "which certainly will admit of explanation upon scientific principles; and I should much like to hear whether you can apply it for that purpose. How does it happen that the cork of the shuttlecock always presents itself to the battledoor?"

"I should think," said George, "that the cork points to the battledoor for the same reason that the weathercock always points to the wind."

"Admirably illustrated!" exclaimed his fa-

ther; "the cork will always go foremost, because the air must exert a greater force over the lighter feathers, and therefore retard their progress. While we are upon this subject, I will introduce to your notice some contrivances which are indebted to this same principle for their operation. In the first place, there is the arrow; can you tell me, Louisa, the use of the feathers which are placed round its extremity?"

"To make its head proceed foremost in the air, by rendering its other end lighter, and therefore more sensible to the resistance of the air," replied Louisa.

"Very well answered; that is, unquestionably, one of the objects of the wings of the arrow; but there is also another, that of *rifling* it, or steadying its progresssive motion, by causing it to revolve around its axis. If you will look at this arrow, you will perceive that the feathers are placed nearly, but not

quite, in planes passing through it; if the feathers were exactly in this plane, the air could not strike against their surfaces when the arrow is in motion: but since they are not perfectly straight, but always a little aslant, the air necessarily strikes them, as the arrow moves forward; by which force the feathers are turned round, and with them the arrow or reed, so that a revolving motion is produced, and its velocity will increase with the obliquity of the feathers. You will therefore observe, that, in order to enable the feathers to offer a necessary resistance to the air, they must possess a certain degree of stiffness or inflexibility. It was on this account that Roger Ascham, and other skilful artists in the days of archery, preferred the feathers of a goose of two or three years old, especially such as drop of themselves, for pluming the arrow; and the importance, as well as the theory of this choice, is confirmed by a curious obser-

vation on the art of archery, '*and it is said that the peacock feather was formerly sometimes used, but seldom or ever did it keep the shaft either right or level.*'"

"That is intelligible enough," said George, "the feather of the peacock must have been so flexible as to have yielded to the slightest breath of air; and now, as we are upon the subject of the arrow, do explain to us the action of the bow."

"I shall readily comply with your request, before we part; but I am desirous, at present, of following up the subject before us, and of taking into consideration some other instruments which owe their motions to the action of the air upon oblique surfaces.

"I was about to explain to you the action of the wind upon the sails of the windmill."

"I should like to hear something about the windmill," said George, "and perhaps you can tell us who invented the machine."

"The invention is not of very remote date," replied Mr. Somers. "According to some authors, windmills were first used in France in the sixth century; while others maintain that they were brought to Europe in the time of the crusades, and that they had long been employed in the East, where the scarcity of water precluded the application of that powerful agent to machinery.

"I had intended," continued Mr. Somers, "to have entered very fully upon the subject of the windmill; for, although it is a very common machine, its construction is much more ingenious than is generally imagined; it must also be allowed to have a degree of perfection, to which few of the popular engines have yet arrived; but to do ample justice to my subject, I should require several models which are not yet in readiness; besides, George's holidays have nearly passed away; I must therefore postpone the exami-

nation of the mill to some future opportunity, and content myself at present with an explanation of its sails.

"My remarks upon the subject will be very general: I shall explain the principle, without entering into the minutiæ of its applications. The vertical windmill, which is the kind in most common use, consists, as you well know, of an axis, or shaft, placed in the direction of the wind, and usually inclining a little upwards from a level line. At one end of this, four long arms, or yards, are fixed, passing through the axis, and across each other at right angles; these afford a surface, on which a cloth can be spread to receive the action of the wind. To conceive why these sails should turn round by the force of the wind, requires very close attention. It is very evident, that if the four sails were set square in the axis into which they are fitted, the wind acting directly against their whole surface, would only tend

to overthrow it. It is necessary, therefore, to have them set aslant in the common axis, that they may receive the wind obliquely, when their effort to recede from it causes them to turn round with the axis: and the four sails being all made aslant in the same direction, thus unite their efforts for the common object."

"Do you not recollect, papa, when we were last in New York, you pointed out to us a curious mill on the banks of the river, which went without any sails?"

"You allude to the horizontal mill. The mill of which you are speaking, consists of a circular wheel, having large boards or vanes fixed parallel to its axis, and arranged at equal distances from each other. Upon these vanes the wind can act so as to blow the wheel round; but if it were to act upon the vane at both sides of the wheels, at once, it is evident that it could not have any tendency to turn it round; hence, one side of the wheel

must be sheltered, while the other is submitted to the full action of the wind. For this purpose it is enclosed within a large framework, which is furnished with doors or shutters, on all sides, to open at pleasure and admit the wind, or to shut and stop it. If all the shutters on one side are open, whilst all those on the opposite side are closed, the wind, acting with undiminished force on the vanes at one side, whilst the opposite vanes are under shelter, turns the mill round; but whenever the wind changes, the disposition of the blinds must be altered, to admit the wind to strike upon the vanes of the wheel in the direction of a tangent to the circle in which they move.

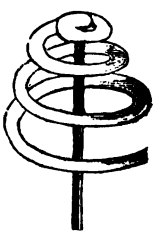
"I will, if you please, now describe to you the mechanism of the smoke-jack; and I am desirous of doing so, as I have a very pleasing experiment to exhibit, which is founded upon the same principle."

Mr. Somers then described the more common form of this machine. It consisted, he said, of a number of vanes, of thin sheet-iron, arranged in a circle, but all set obliquely at a proper angle of inclination. Its action was explained in the following manner: When a fire is kindled in the chimney, the air which, by its rarefaction immediately tends to ascend, strikes on the surfaces of the inclined vanes, and causes the spindle, to which they are affixed, to turn round, and consequently communicates the same motion to the spit. The brisker the fire becomes, the quicker will the machine move, because in that case, the air ascends with greater rapidity.

"I will now exhibit to you an amusement which is founded on the same principle," said Mr. Somers. "Fetch me the piece of pasteboard which lies on the library table."

The pasteboard was produced, and Mr. Somers described upon it a spiral. The spiral

was cut out, and extended, by raising the centre above the first revolution. It was then suspended upon a small spit of iron, which had been previously prepared, by applying the centre or summit of the spiral to its point. The whole was now placed on the top of a warm stove, (the application of a lamp would have answered the same purpose) and the machine, to the great delight and astonishment of the children, soon put itself in motion, and turned without the assist-



ance of any apparent agent. The agent, however, in this case, was the air, which being rarefied by the contact of a warm body, ascen-

ded, and thus produced a current. The accompanying sketch may render this experiment more intelligible to the reader.

Mr. Somers here remarked, that he had once seen a similar contrivance, which many consider the effect of clockwork.

"And what might that have been?" asked George.

"The revolution of a serpent, which I noticed in several windows in New York, during an illumination. It was nothing more than a spiral, so painted as to resemble that reptile, and which owed its motion to the action of air heated by a lamp placed beneath it."

Our little philosophers were absent till a late hour in the afternoon, on a nutting excursion.

"And where have you been strolling?" said Mr. Somers to the children on their return.

"Into Thornberry wood, papa, where we have collected two large bags full of nuts;

and whom do you think we met on our return?"

"How can I possibly answer that question?" replied Mr. Somers.

"Mr. Richdale, papa; who says he has returned for a few days only, and that he intends to set off for Europe in the beginning of next week."

"Indeed!" exclaimed Mr. Somers; "and did he send any message to me?"

"No; but he asked whether you had not been lately teaching us the operation of the various toys, which act by the force of the air; and when we told him that you had taught us the reason of the kite's ascent, and the nature of the squirt, sucker, and pump, he gave us this paper, and desired us to open it in your presence, and to send him such an answer as it may require."

"I perceive from the superscription that it is a riddle," said Mr. Somers.

"A riddle!" exclaimed Louisa; "how delightful! Pray read it, papa, and let us try to discover its meaning."

Her father then opened the letter, and read as follows:—

"Mortal, wouldst thou know my name,
Scan the pow'rs I proudly claim.
O'er this globe's capacious round
With fairy sprightliness I bound;
To ev'ry clime, to ev'ry soil,
With equal hand I give my toil.
O'er sea and land my power extends,
To ev'ry herb my care descends.
Did I withdraw my vital breath,
Nature's form would sink in death.
When confin'd, or swiftly driven,
By angry spirits in the heaven,
My wrath in thunders I make known,
And Discord claims me as her own.
'Tis love of freedom makes me wild,
When uncontroll'd my nature's mild;
And oft the nymph, in dewy grot,
Seeks solace from my plaintive note;
O'er lover's graves I waft a sigh,
And breathe the sound of sympathy.
And know, ye sons of Albion's Isle,
That when the Hero of the Nile,

Midst crowds with mourful pomp array'd,
In the cold lap of Earth was laid,
I sympathis'd with Britain's tear,
And waved the banner o'er his bier.
'Tis I, who, from the trembling lyre,
Breathe notes of love and soft desire;
'Tis I, the spirit of the shell,
Who fill with notes the listening dell;
And, when the war-trump sounds alarms,
'Tis I who summon men to arms,
To man a slave, though free as air,
I grind his corn, his food prepare;
Should he to foreign climes proceed,
He yokes me like the neighing steed,
And, by my quick but easy motion,
He traverses the mighty ocean.
His children, too, my presence court,
To give them toys, and make them sport;
Without my aid, their kites would lie
As useless weights that ne'er could fly;
Their humming tops would soundless spin,
Unless I breath'd a spell within.
The modest maid without my power,
Would wither like her kindred flower,
Unless my cup of sweets she sips,
Where are the rubies of her lips?
Unless my glowing rouge she seeks,
Where are the roses of her cheeks?
What art, again, can strew her tresses,
With half the grace my skill possesses?

Ev'n goddesses are represented
In draperies which I invented.
Sometimes, 'tis true, I am so frail,
As ruffian like to raise your veil,
And thus to curious man reveal
The charms you modestly conceal.
Revenge the deed. Announce my Name,
For now you know the powers I claim."

"It is extremely pretty," exclaimed Louisa.

"It is beautiful," said George; "but I should like to find out the riddle it contains. What can that be which grinds our corn, and carries our ships across the sea? Canvass? Yes; canvass clothes the sails of the windmill, and forms those of the ship."

"And therefore visits every clime; while, as long as the sails remain fixed, they are quite tractable and steady," added Louisa.

"It will not do, Louisa; it cannot be canvass: for the sail is never boisterous when it can be controlled; but when let loose, it shivers in the wind and is very unruly; whereas it is said in the riddle, 'When uncontroll'd

my nature's mild,' which is quite the reverse. Let me see. Can it be string? My top could not hum without string."

"How can string prevent the modest maid from fading like a flower?" asked Louisa.

At this moment Mrs. Somers whispered in the ear of her little daughter, who shortly afterwards exclaimed, "I have it, George—it is AIR."

The juvenile group now attentively perused the riddle, in order to discover whether its different parts would admit of such an interpretation. As soon as they arrived at the passage in which was described the waving of the banners over the bier of Nelson, George declared that his sister must be wrong; and was proceeding to offer his reasons, when Mr. Somers interrupted him, by observing, it was that passage which first suggested to his mind the solution of the riddle; and satisfied him that Louisa was perfectly right.

"It so happened," continued he, "that I was present during the awful ceremony of Nelson's interment; and never shall I forget the thrilling effect which was produced on the assembled multitude, by the solemn movement of the banners in the dome, as the bier slowly advanced along the aisle of the cathedral; and which was accidentally occasioned by a current of air from the western entrance, although, to the eye of fancy, it seemed as if some attendant spirit had directed the colors, under which the hero had bled and conquered, to offer this supernatural testimony of respect and sorrow."

"I believe," observed Mrs. Somers, "that the pastime of riddle-making was extremely ancient. It was popular amongst the Grecians. Plutarch, if I remember correctly, has told us that the girls of his time worked at netting or sewing, and that the most ingenious amongst them 'made riddles.'"

"The most ancient riddle on record," said Mr. Somers, "is to be found in the fourteenth chapter of the book of Judges."

"*And Samson said unto them, 'I will now put forth a riddle unto you; if ye can certainly declare it me within the seven days of the feast, and find it out, then I will give you thirty sheets and thirty changes of garments.' And they said unto him, 'Put forth thy riddle that we may hear it.' And he said unto them, 'Out of the eater came forth meat, and out of the strong came forth sweetness.'*"

"And did they find it out?" asked George.

"My dear boy," replied his father, "you must read the chapter to which I have alluded, and you will thence learn all about this riddle."

"We have also numerous riddles in profane writers of ancient date. Did you ever read of that invented by Cleobulous, one of

the seven wise men of Greece, who lived 570 years before Christ?"

"Pray be so kind as to relate it," said George.

Mr. Somers, in compliance with this request, proceeded as follows:—

"There is a father with twice six sons; these sons have each thirty daughters, who are parti-coloured, having one cheek white, the other black. They never see each others' faces, nor live above twenty-four hours."

"A very strange and unsociable family!" observed Louisa.

"I should never guess it," said George, "if I were to dedicate a year to it."

"You have, nevertheless, my boy, just pronounced the name of the said father, and that, too, after a single moment's consideration."

"The name of the father!—how?—where?"

"It is a YEAR."

"A year!" exclaimed the astonished boy.

"A year!" echoed Louisa; "to be sure it is; I now see it all clearly. His 'twice six sons,' are the twelve month; the 'thirty daughters,' the days of each month; and, since one day must necessarily pass away before the next can arrive, they may be truly said never to see each others' faces."

"Admirably expounded!" said her mother.

"And each day," added George, "is certainly 'parti-colored,' as it is made up of light and darkness."

Mr. Somers, willing to turn the current of conversation into a more profitable channel, seized this opportunity.

"What interests you, George," said Mr. Somers, who perceived by the inquiring and animated countenance of the boy that his attention had been excited by some occurrence.

"I have been watching the woodman," said George, "and have been astonished to observe that the sound of his hatchet was not

heard until some time after he had given the stroke."

"And has the reason of it never been explained to you?" asked Mr. Somers.

"It has," replied George, "and I have been told that it is owing to sound travelling so much slower than light."

"You are quite right, and it may not be amiss here to inform you, that this fact furnishes a very beautiful method of calculating distances. The stroke of the axe is seen at the moment the woodman makes it, on account of the immense velocity with which light travels; but the noise of the blow will not reach the ear until some time has elapsed, the period varying of course in proportion to the distance, because sound moves only at the rate of eleven hundred and forty-two feet in a second, or about thirteen miles in a minute; so that you perceive, by observing the interval between the fall of the hatchet and

the sound produced by it, we can ascertain the distance of the object."

Mr. Somers fixed his eye attentively on the woodman, and, after a short pause, declared that he was about a quarter of a mile distant.

"Why, how could you discover that?" cried Louisa, "you had not any watch in your hand."

"But," said Mr. Somers, "you might have perceived that I placed my finger on my wrist, and as my pulse beat about seventy-five strokes in a minute, I was able to form a tolerable estimate of the interval, although I confess that it is a very rough experiment, but sufficiently accurate for the purpose of illustration. In the same manner we can readily ascertain the distance of a thunder-cloud, or that of a vessel at sea, firing a cannon. If we do not hear the thunder till half a minute after we see the lightning, we are to conclude the cloud to be six miles and a half. By ob-

serving the number of seconds also which a stone requires to descend from any height, we can discover the altitute or depth of the place in question."

Louisa, who had been attentively listening to her father's explanation, pulling George towards her, whispered something which was inaudible to the rest of the party.

"Come, now," exclaimed Mr. Somers, "I perceive by your looks that you have something to ask me. Louisa is sceptical again."

"O dear, no," replied George. "Louisa merely observed, that we might thus be enabled to find out the depth of the village well, about which we have all been very curious."

"Then we will walk to the well," replied Mr. Somers, "and make the experiment."

After a walk of a few minutes, the party arrived at the place of destination.

"Now, George," asked his father, "how will you proceed?"

"I shall drop the stone into the well," replied George, "and observe how many seconds it will be before it touches the water, and I shall then multiply the number of feet which a body falls in a second by the number of seconds which the stone is in falling."

"Let me tell you, my fine fellow, that this will never accomplish your object, for the velocity of a falling body is continually increasing, or it has what is called an accelerating velocity; it has accordingly been ascertained that a body descending from a considerable height, falls sixteen feet in the first second of time, but three times sixteen in the next, five times sixteen in the third, and seven times sixteen in the fourth, and so on, continually increasing according to the odd numbers 1, 3, 5, 7, 9, 11, &c. But are you ready to count the seconds?"

"Quite ready."

"Here goes the stone."

"One—two—three—four."

"There," said George, "it touched the water. It descended in four seconds."

"Now, my boy, make your calculations."

Mr. Somers furnished pencil and paper, and George proceeded:—*Sixteen* feet for the first second,—I put that down."

"Well," said his father, "and three times sixteen for the second."

"Forty-eight," cried George.

"Put it down."

"Five times sixteen for the third."

"Eighty."

"Down with it.

"And seven times sixteen for the fourth."

"One hundred and twelve."

"Now cast up these numbers," said Mr. Somers.

"Two hundred and fifty-six feet," cried George, "is the depth of the well."

A shout of delight from George and Lou-

isa announced the satisfaction they felt at the success of their experiment.

The party soon after this returned home, where, after the usual ceremonies of the toilet, they sat down to tea, in the enjoyment of which we will leave them, and put an end to the chapter.

CHAPTER VIII.

No sooner had our party assembled on the following morning, than Mr. Somers resumed the subject of his lectures.

"We have lately," said he, "considered the phenomenon of wind, as produced by the motions of the atmosphere, and I now propose to investigate another species of agitation of which the air is susceptible, a kind of vibratory or tremulous motion, which, striking on the drum of the ear, produces SOUND."

"Is it the air which produces sound?" said Louisa, with much surprise, "I thought it was always occasioned by the vibrations of solid bodies. Well do I remember, when George struck the finger-glass, that you immediately silenced the sound by placing your hand upon it, and which you told us stopped the vibration of the glass, and so destroyed the sound."

"You speak the truth, but not the whole truth," replied her father. "Sound is undoubtedly the result of certain motions, or vibrations, produced in sonorous bodies, but these vibrations are communicated to the air, and from thence to the ear, in a manner which I shall presently explain."

"Do you mean to say, papa, that, if air were entirely excluded, bodies would be incapable of producing sound when struck?"

"Not exactly. Air is the usual conductor of sound, and unless some other medium be substituted, the removal of it would prevent a sonorous body from communicating any sensation to the ear. Liquids, however, are capable of conveying the vibratory motion to the organ of hearing; for sound can be heard under water. Solid bodies will also convey it, and in a much more perfect and rapid manner; thus the slightest scratch with a pin, upon one end of a long piece of timber, will

be distinctly heard on applying the ear to its opposite extremity. The trampling of a horse is to be perceived at a greater distance by listening with the ear in contact with the ground, than by attending to the sound conveyed through the air. Upon the same principle, if we place our ear against a long brick wall, and desire a person at a considerable distance to strike it *once* with a hammer, it will be heard *twice*, the first sound travelling along the wall, the second through the air."

"I thank you for that hint," said Mrs. Somers. "I now understand the principle of a new instrument which Dr. Doseall employs for examining the pulsations of the heart. He places the end of a wooden tube upon the breast, and, applying the other extremity to his ear, declares that the sounds, thus conveyed to it, enable him to form the most accurate opinion in cases of diseased chest.

"In the same manner, I suppose," continu-

ed Mrs. Somers, "that you may hear the boiling of the tea-kettle, by placing the end of the poker on the vessel, and applying your ear to the handle."

"I do not exactly understand what you mean by a *sonorous* body. Will not every body produce a sound when struck?" asked Louisa.

"Those bodies are called *sonorous*, which produce clear, distinct, regular, and durable sounds, such as a bell, a drum, musical strings, wind instruments, and so on."

"And upon what does this peculiar property depend?" inquired George.

"Before I answer that question, I must explain the supposed nature of those vibrations of the air, upon which sound depends; you will then readily perceive why one species of matter should be better calculated than another for exciting them. It is generally believed that sound is conveyed through the air

by a succession of pulsations similar to those which are occasioned on the surface of smooth water by throwing a pebble into it. This at first produces a small circular wave round the spot in which the stone falls; the wave spreads, and gradually communicates its motion to the adjacent waters, producing similar waves to a considerable extent. The same kind of waves are produced in the air by the motion of a sonorous body, which will of course be in the centre, and the waves or pulsations will diminish in strength as they recede from that centre, until at last they become too weak to produce any effect on the ear."

"When I strike a bell, then, do I produce exactly the same motion in the air, that I do in the water by throwing a stone into it?" asked Louisa.

"With this difference," replied her father, "that, as air is an elastic fluid, the motion

does not consist of regularly extending waves, but of vibrations, and are composed of a motion forwards and backwards; the undulations of the air differ also from those of the water, in not being confined to a plane, but in diverging in all directions from the centre."

"It is a very puzzling subject," cried George.

"I cannot understand," said Louisa, "how the motion of the air can extend so as to convey sound to a distance, if, as papa says, the air moves backwards as well as forwards."

"I see your difficulty, and will endeavor to remove it; attend to me. The first set of undulations which are produced immediately around the sonorous body, by pressing against the air, condense it. The condensed air, though driven forward by the pressure, re-acts on the first set of undulations, driving them back again. The second set which have been put in action, in their turn, communicate their motion, and are themselves driven back by

re-action. Thus there is a succession of waves in the air, corresponding with the succession of waves in the water."

"Now I understand why sound requires some time to travel from a distant object to the ear," said Louisa.

"But you have not yet told us what renders a body sonorous," observed George.

"Its elasticity: a ball of damp clay, which does not possess this property, will produce no other sound, when struck, but that which arises from the condensation of the small portion of air between the clay and the hammer which strikes it. A hollow ball of brass will produce more sound, because it is elastic; but still very little effect will arise from this, since a ball is the worst shape for admitting of vibration, on account of its forming an arch or dome, in every direction, so that one part stiffens and sustains the other: but if such a ball be divided, and the edge of one

half of it struck, a loud, clear, and distinct tone will be produced; because a hemisphere will admit of the exertion of elasticity, or of momentary change of figure, which is conducive to the perfection of sound; and accordingly the bells used for clocks, and for musical purposes, have generally such a figure."

"I see clearly," said Louisa, "that it is the vibration of a sonorous body that communicates the necessary motions to the air; and I suppose that a body vibrates in proportion to its elasticity. And I now understand how sound is produced and carried to a distance. I should much like to learn the cause of different tones."

"Fond as you are of music, my dear Louisa, I am not surprised at the wish you have just expressed to become acquainted with the nature of musical sounds: I shall, therefore, endeavor to convey, in as simple a manner as possible, the theory which has been

proposed for their explanation. I think you will immediately perceive that, if the aerial waves which I have endeavored to describe, should be irregular, or run into each other, there must arise a confusion of sounds; thus *discords* may be readily imagined to be produced whenever a second vibration shall commence before the first is finished, so as to meet it half way on its return, and interrupt it in its course. In like manner may we conceive the general nature of those arrangements upon which *unison* and *concord* depend: where the vibrations are performed in equal times, the same tone is produced by both, and they are said to be *in unison*; but *concord*, as you well know, is not confined to unison, for two different tones harmonize in a variety of cases. If, for example, the particles of one sonorous body vibrate in double the time of another, the second vibration of the latter will strike the ear at the same instant as the first

vibration of the former, and this is the 'concord of an *octave*.' When the vibrations are as 2 to 3, the coincidence will be at every third vibration of the quickest, which therefore is the next degree of perfection, and is called a 'fifth;' while the vibration of 3 to 4 will produce the 'fourth;' but this, and the next which follow in order, are not so agreeable to the judicious ear, and are therefore called '*imperfect concords*.'"

Louisa here inquired whether the difference in the acuteness of a sound did not depend upon the nature of the vibrations: and her father, in reply, stated that it depended entirely upon the degree of quickness with which the vibrations were performed: the slower the vibrations, the graver the tone; the quicker, the more acute.

"But, if I strike any one note of the instrument repeatedly, whether quickly or slowly,

it always gives the same tone," observed Louisa.

"To understand that fact," replied her father, "you must remember that the vibrations of bodies are regulated by peculiar laws; the duration of the vibrations of strings or cords depends upon their length, and thickness, for if two strings of equal magnitude, but with their length as 2 to 1, be equally stretched, their vibrations will be in the same ratio; therefore the shortest will make two vibrations while the longest makes one: but the vibrations of the same string will always be the same whether it be struck quickly or slowly."

Louisa here remarked that she had often heard of some very extraordinary echoes in different parts of the world, to which her father had not alluded; she mentioned, for instance those which are said to repeat the same sound several times in succession.

"From the explanation which I have already given of the nature of echoes," said Mr. Somers, "it will be easily conceived that a vast variety of effects may be produced by varying the form, the shape, the distance, and the number of reflecting surfaces; and hence we hear of various surprising echoes in different places. It is not difficult, for instance, to understand the nature of compound, or tautological echoes; in which case the expression of one *ha* will appear like a laughter. Addison mentions an extraordinary instance of this kind near Milan, which will return the sound of a pistol fifty-six times."

"I have understood that the echoes on the lakes of Killarney are of this multiplied description," said Mrs. Somers.

"They are particularly calculated to produce reflections of sound, from the height of the mountains, and the expanse of water," replied Mr. Somers, "which latter circumstance

always assists the conveyance of reflected, as well as direct sound. I believe that there is a certain spot on the shore of Ross island, where the sound of a bugle produces an echo which far exceeds any other to be met with; the first echo is returned from a castle, the second from a ruined church, the third from Mangerton, and afterwards innumerable reverberations are distinguished, which, like the faded brilliancy of an extremely multiplied reflection, are lost by distance and repetition.

"There is an admirable echo," continued Mr. Somers, "behind the college at Cambridge; and often have I, on a calm evening, distinctly heard twelve repetitions of the voice. Lord Bacon, if I remember correctly, mentions an instance of sixteen, in the church of Pont-Charenton, near Paris, on the Seine; in which place that great philosopher discovered the inability of an echo to return the

letter S, for having pronounced the word *satan*, the echo replied *va-t-en*, which in French signifies *away;* from which circumstance the Parisians concluded that some guardian spirit prevented the walls of the sacred edifice from pronouncing the name of *satan.*"

"And will not an echo repeat the letter S?" asked Louisa.

"Not always," answered her father; "the hissing or sibilant noise of the letter, when at the commencement of a word, is generally lost, unless the echo be extremely perfect."

Mr. Somers now produced a shell, and desired George to place it to his ear.

"I hear a noise which appears to me to resemble that of the sea," cried George.

"Yes," said Mr. Somers, "and there is a popular belief that it is the murmur of the sea, which the shell actually sends forth; betraying, as it were, its marine origin."

"And what produces the sound?" inquired Louisa.

"The interior of the shell merely concentrates, and thus multiplies the sounds around us, so as to render them audible; a goblet applied to the ear will be found to produce the same effect," replied his father.

"I suppose it is upon the same principle that the speaking trumpet is made to convey sound to a distance," remarked Louisa.

"Since sound radiates in all directions, it follows, that, if such radiation be prevented by confining it in tubes, it may be carried to a great distance, with very little diminution of its effect; and hence the use and application of those trumpets, or tin speaking-pipes, which are now commonly used for conveying intelligence from one part of a house to another. The trumpet used by deaf persons acts on the same principle; but as the voice enters the trumpet at the large, instead of the

small end of the instrument, it is not so much confined, nor is the sound so much increased."

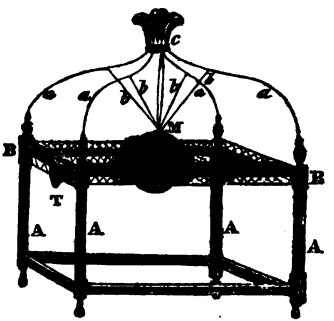
"I believe," said Mrs. Somers, "that the experiment exhibited some time since in London, under the title of the *Invisible Girl*, and which excited such general curiosity, was discovered to depend upon an arrangement of this kind."

"I expected that you would allude to that exhibition," said Mr. Somers; "and as I was anxious to provide my young pupils with some new amusement, as a reward for their industry, I have directed the carpenter to construct the necessary apparatus for exhibiting and explaining the deception."

The children were now introduced into the apartment containing the apparatus necessary for explaining the *Invisible Girl.*

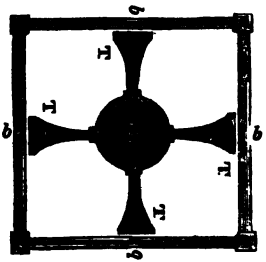
We shall proceed to describe all the visible mechanism, as it appeared to the children on entering Mr. Somers' study, and of which we

here present the reader with a perspective sketch. It consisted of a wooden frame, not very unlike a bedstead, having four upright posts, AAAA. and a cross rail at top and bottom to strengthen them. The frame thus constructed stood upon a low table, and from



the top of each of the four pillars sprang four bent brass wires, which met in the point *c*. From these wires a hollow copper ball M., was suspended by four slender ribands, so as to cut off all possible communication with the

frame. The globe was supposed to contain the invisible being, as the voice apparently proceeded from the interior of it; and for this purpose it was equipped with the mouths of four trumpets, placed round it in a horizontal direction, and at right angles to each other, as shown in the annexed section, in



which the globe is represented in the centre; T T T T are the trumpets, and *b b b b* the frame surrounding them, at the distance of about half an inch from their mouths.

Such as we have described was the apparatus which had been constructed under the

direction of Mr. Somers, who informed the party that, if any of them would ask a question of his little fairy, and direct the voice into one of the trumpets, an answer would immediately be returned from the ball.

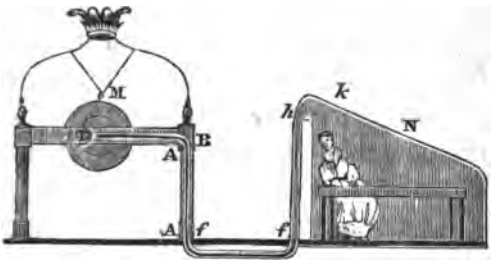
"Let me interrogate her," exclaimed Louisa, as she advanced towards the railing. "Tell me, mysterious being, the name of the person who now addresses you."

"Miss Louisa Somers," answered a voice sufficiently audible to Louisa, whose ear was near the mouth of the trumpet, and yet so distant and feeble, that it appeared as if coming from a very diminutive being, and thus heightened the deception. Each of the party successively asked one question; and the surprise of the children may be more easily imagined than described. George examined the ball, the trumpets, and the framework; but he was unable to discover any clue by which he could unravel the mystery. At length Mr.

Somers proceeded to the explanation. He told them that the mechanism owed its effects to the combined operation of two principles, with which they were already acquainted; the concentration and conveyance of sound by means of a speaking-pipe, and its reflection from an appropriate surface so as to change its apparent direction, by producing an artificial echo. He then showed them the pipe which was concealed in one of the legs of the frame, and explained in what manner the voice of the carpenter, who had been stationed in an adjoining room, was conveyed to the mouth of the trumpet, and thence reflected to the ear of the observer. By means of the annexed section, we shall hope to render this subject as intelligible to our readers, as did Mr. Somers to his little pupils.

BB. represent two of the legs of the frame, one of which, as well as half the rail, is made into a tube, the end of which opens immedi-

ately opposite to the centre of the trumpet. This hole is very small, and concealed by mouldings; the other end communicates by a tin pipe, which passes, in a concealed



manner, along the floor of the room, into an adjoining closet, where the confederate is concealed. It is evident that any sound, directed into the mouth of the trumpet, will be immediately reflected back to the orifice of the tube, and distinctly heard by a person who places his ear to the mouth of the funnel, *h*; while the answer returned by him, travelling along the tin funnel, will issue from its

concealed orifice, and striking upon the hollow surface of the trumpet, be returned to the ear as an echo, and thus appear as if it had proceeded from the interior of the ball.

Mr. Somers observed, "that this deception of the *Invisible Girl*, which had formerly created so much interest, was little more than the revival of the old and well-known mechanism of the *speaking bust*, which consisted of a tube, from the mouth of a bust, leading to a confederate in an adjoining room, and of another tube to the same place, ending in the ear of the figure; by the latter of which, a sound whispered in the ear of the bust was immediately carried to the confederate, who instantly returned an answer by the other tube, ending in the mouth of the figure, which therefore appeared to utter it. The Invisible Girl evidently only differs from that contrivance in this single circumstance, that an artificial echo is produced by means of the trumpet,

and thus the sound no longer appears to proceed in its original direction.

"As this is the last day of George's vacation," continued Mr. Somers, "we shall be obliged to suspend here our amusements in philosophy. When the next holiday commences we will continue our recreations on another subject. In the mean time, however, I hope you will never use your leather sucker without remembering that the air is a substance, and exerts a pressure; that whenever you wonder how a fly can walk on the ceiling with its head downwards, you will call to mind the nature of a vacuum; that when you use your pop-gun, you will consider the elastic properties of the air; and in a word, that blowing soap-bubbles, working the pump, or flying the kite, will suggest to your mind some important truths which you have learned respecting the atmosphere."

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